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ABSTRACT

Outdoor education, which should be complementary to classroom work, is all of that learning which takes place in and about the outdoors. This book, which is aimed primarily at teachers and student groups, is a useful aid to those who may wish to investigate and explore the rich natural outdoor environment and consists of investigations which are designed to give students an insight into the ecological practices and principles used in the investigation of woodlands, bogs, moorlands, and lakes. The booklet is divided into two main areas: the first part consists of a description of the habitats at a height of 400 feet about sea level and a number of investigations for those areas; the second part has a brief geological description of the Cappanalea area in Ireland and a few investigations which deal specifically with this region. The investigations in the first part are grouped according to habitat, with sections on woodland, bogland/moorland, and the lakes/rivers. A section on general investigations is also included. Each investigation is graded as either introductory or advanced and includes an introduction, equipment list, procedure, results, and points for discussion. (MKR)

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Field Studies

ONE STEP INTO THE OUTDOORS

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Tony Murphy

Field Studies

ONE STEP INTO THE OUTDOORS.

Tony Murphy B Sc (Ed.)

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* Introductory
** Advanced

PREFACE

Outdoor education, which should be complementary to classroom work, is all of that learning which takes place in and about the outdoors. It is an inter-diciplinary process and has a unique role to play in affecting the comprehension of an attitude towards the environment.

This book, which is aimed primarily at teachers and student groups, is a useful aid to those who may wish to investigate and explore the rich natural outdoor environment. While much of the research associated with developing this work was undertaken at the Outdoor Education Centre, Cappanalea, Co. Kerry, the material contained in the book and the activities suggested are not "location bound". This book may be effectively used by teachers and student groups to investigate and explore a variety of suitable habitats in any part of Ireland.

Students who are following prescribed courses of study at junior or senior cycle level in second level schools will find the range of the investigations most relevant to their studies. They are given the opportunity of experiencing "hands-on" investigations of phenomena observed in the natural environment. A scientific methodological approach is developed throughout the suggested investigations as students are encouraged to observe phenomena, recall results, research information and discuss and draw conclusions from their work. This approach to outdoor education, coupled with well planned follow up work and using the facilities of the school laboratory and/or appropriately equipped outdoor education centres, provides an excellent learning environment.

Francis J. McGourty,
Head of General and Rural Science Department,
Thomond College of Education,
Limerick.

INTRODUCTION

The woodland, bogland, moorland and the lake are exciting and interesting places to visit and study. With patience and observation many new experiences can be enjoyed, mysteries can be solved and the insignificant can become the significant. Any one of the above areas can be used to study ecology, as each exhibits relationships between flora (plants) and fauna (animals).

This booklet consists of investigations which are designed to give the Leaving Certificate student an insight into the ecological practices and principles used in the investigation of the above areas. It is primarily aimed at the post-primary Leaving Certificate ecology section of the Biology syllabus.

The booklet is divided into two main areas: the first area consists of a description of the habitats at a height of 400 ft. above sea level and a number of investigations, the back of the booklet has a brief geological description of the Cappanalea area and a few investigations which deal specifically with this region.

The investigations in the first part of the booklet are grouped according to habitat, with sections on woodland, bogland/moorland and the lakes/rivers. A section on general investigations is also included.

(These general investigations can be performed in transition year, etc., in the second level syllabus.)

Each investigation is graded as either introductory (*) or advanced (**). It is suggested that some introductory investigations be carried out before progressing to the advanced ones.

A list of other suggested investigations is given at the end of each section.
When each investigation has been completed, the results should be carefully analysed and discussed. However, do not be very disappointed if the results are not textbook results, as new discoveries are often made in this way. It is important to attempt to explain all the results, especially if they differ from previously learned ecological principles.

The outdoor experience, followed by the indoor discussions and write-up of the investigation, completes the learning cycle.

This booklet is arranged so that the student can use it on his/her own, or the teacher can become involved in the investigations with the students.

Remember that the investigations listed here are only a small fraction of those that can be performed.

The attitude of the students towards their natural environment is very important. A sense of conservation and the need for it should be instilled in the students. Conservation education is necessary in this modern world where whole habitats (i.e. marshes, bogs, forests) are being destroyed without regard to the full impact of this destruction on the delicate ecological balances. People need to realise that this cannot go on forever without affecting us. Our survival as a species needs to be examined not apart from the natural world but as part of it. This booklet should at least help the students to make contact with their natural environment in a meaningful and constructive way.

Finally, the booklet can be used (with minor modifications) in any area of the country which has these habitats.

FIELD STUDIES AND THEIR RELEVANCE TO THE CURRICULUM.

Both the Intermediate and the Leaving Certificate syllabi contain sections dealing with Field Studies. The main aims of these are to **"put into practice the principles introduced"** in the theoretical ecology course and that **"the student should become familiar, through first-hand observation, with the flora and fauna of the selected habitat"**. (Rules and Programmes for Secondary Schools). Both of these aims can only be achieved through practical experiences outdoors.

The methodology used in the investigations is typical of that required for examination questions in the ecology section of the Leaving Certificate, while other investigations can contribute to different areas of the Biology syllabus. For example, the detection of microorganisms in water (Investigation No. 18) can be used in the microbiology section.

Many teachers may wonder if Field Studies are necessary or relevant in the school syllabus. Examinations apart, the need for young people to have an understanding of their natural environment was never greater. **"In general terms what is suggested here is the encouragement of awareness, understanding and concern for the environment both locally, nationally and worldwide"**. (Booth 1984)

These activities should not be seen as an independent course but complementary to other areas of study bringing the syllabi 'alive' and making them relevant to the student. In this way, the need for conservation can also be highlighted.

The outdoors has always been a fantastic, exciting and motivating place and any teaching method should not stifle these characteristics. It is amongst the greatest teaching resources that one can have.

A teacher should not be over-anxious about teaching outdoors because he/she lacks equipment. The equipment can come from a variety of natural sources. Instead of using a quadrat why not use some twigs to represent the four points and some twine to close off the area? The pupils could measure or pace out the distance to the size required.

The outdoors provides the opportunities for an interdisciplinary approach to learning, allowing scope to cover most, if not all, subjects. However, the ultimate success of any teacher will be his/her ability to blend his/her interests with a programme and an audience. Use different teaching methods - be creative - attempt to teach every fact imaginatively and in an exciting manner **(Link, 1981).**

Creativity, Imagination and Determination are the Ingredients of Success. (Link, 1981).

Your expertise may not be vast on your first outing, but both you and the pupils will be learning about the natural environment. After a number of visits to areas, your confidence and expertise will be such that you feel at ease teaching in the outdoors. Man first learned from his environment, now he needs to return to this setting to learn again.

Certainly in the area of Field Studies, the outdoors needs to be used as a resource and the need for environmental education (i.e., geography, geology, ecology, etc.) is constantly increasing.

While this booklet deals with ecological principles mainly, you should keep in mind that other areas of the curriculum can be incorporated into a field visit or outdoor education. You, as a teacher, should devote energy towards creating a better and more comprehensive knowledge of the environment in your pupils. Nature will inspire and motivate people, but for many, you are the first bridge towards the care and understanding of the area we call the GREAT OUTDOORS.

Finally, **"if one accepts the premise that the outdoors is a good place for achieving some of the accepted goals of education more effectively than can be done in the classroom alone, then education experience outdoors become an integral part of a general education."** (Smith et al, 1984).

NOTES ABOUT EACH INVESTIGATION

Each investigation is outlined under various headings:

Introduction: A brief introduction to each investigation giving background information and the aims of the investigation with a suggestion as to the best time of year to engage in the particular work.

Equipment: A list of the equipment needed for each investigation.

Procedure: This outlines the steps and methods to be used to perform the investigations.

Results: Various ways of showing your results are suggested with some examples included.

Points for Discussion: A list of headings on which the conclusions may be based.

These are just a few of the headings which might be considered. Feel free to add additional headings should the need arise.

Encourage your students to develop the art of recording information gained, observations made and procedure, etc. At the conclusion of an investigation, make sure that a record is made. You may find the headings suggested above useful in encouraging an analytical and scientific approach.

NOTES FOR THE TEACHER

Preparation For Fieldwork

The performance of any type of fieldwork in an accurate and professional manner requires organisation and a considerable amount of thought. To a certain extent the success of the fieldwork will depend largely on the planning afforded it; therefore the following points should be noted before visiting the study areas:

1. Decide on which habitat you will visit.
2. Get information on weather conditions for the area.
3. Read the appropriate sections of this booklet.
4. If you are going with a group, discuss with the others, the work to be carried out and allot tasks to each member (the teacher or the group leader can do this).
5. Collect and prepare the required equipment for the projects. Allow for breakages and losses.
6. Collect the required clothing for the weather conditions forecast - ALWAYS BE PREPARED FOR THE WORST!!!!!!!!!
7. ALWAYS KEEP SAFETY FIRST. Never wander too far away without informing someone and never try to carry out investigations in dangerous areas, such as cliffs, unless an experienced person is with you.
8. REMEMBER YOUR FIRST-AID KIT. Get any relevant medical information concerning your group before you leave. For example, don't wait until you are half-way up a hill to learn that a member of the group has diabetes or asthma.
9. DON'T FORGET - GET PARENTS PERMISSION AND THAT OF THE SCHOOL/CLUB BEFORE YOU GO ANYWHERE. This is very important, particularly for INSURANCE PURPOSES.

Treat The Area With Care

When you visit any area to carry out investigations, you have a responsibility to leave the place as you found it. Your intrusion into the area should not cause damage of any kind. Therefore, follow these simple rules:-

- Do not leave litter, especially papers and silver foil, around the area;
- Ask permission if you have to cross someone's land;
- Do not take specimens which are uncommon, such that only one or a few specimens are discovered by a group after a considerable search, i.e. in the Kerry area, the Spotted Slug. If collecting animals for preservation, kill them humanely with the least amount of suffering involved.
- Do not take specimens unnecessarily, take only plants and animals that you cannot identify at the collection site. If in a group, only one member should collect specimens and then less than five should be collected.
- When sampling, plan so that as little destruction as possible occurs. Indiscriminate sampling, especially by a large group, can exert a lot of pressure on a habitat.
- If possible do not sample. Many organisms can be identified by sight or by sketching for later identification, e.g., birds, some insects.

Identify Without Destructive Sampling

- Never try to transplant flora, especially unusual types, from their natural habitat because they will die. They have evolved to this particular habitat and will perish in any other.
- Many invertebrates are found by searching under stones, fallen logs or other plant debris. It is very important to replace these objects in their original position, otherwise the micro-climate will be destroyed, causing certain death to the creatures which inhabit this micro-habitat.

- WILDLIFE ACTS have been implemented to conserve certain species. For example, it is now illegal to collect frog spawn without a licence. This is due to the fact that the common frog has become very scarce as a result of excessive collecting. Students and teachers should be aware of the various plants and animals that are protected under these laws and help in their conservation. (See Appendix)

- The need to conserve natural areas from development has never been greater. The pressures by man on the natural environment have caused great problems in the past and continue to cause difficulties. Now is the time to think of the future, conserving these areas for the next generation. Conservation education is needed now to create an interested and informed youth who will protect their natural environment and be ready to argue for its care and preservation.

EQUIPMENT AND TECHNIQUES

A list of necessary equipment is given for each investigation. In addition, the following is a list of basic equipment needed for all investigations:

(1) Plastic bags and small bottles for carrying specimens.
(2) A jar for lakewater and aquatic specimens.
(3) A notebook/record sheets and pencils for recording.

This section describes some techniques which have an important role in ecological fieldwork.

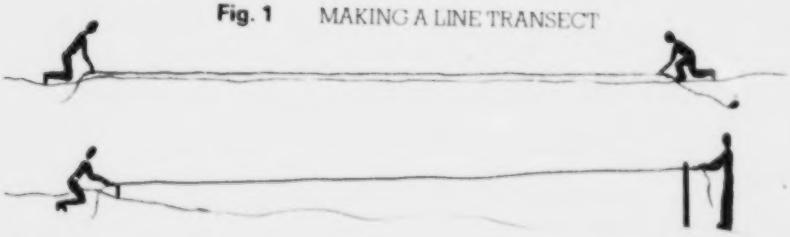
Transects and Quadrats

Transects, using builders twine (orange, waterproof type), can be easily and quickly prepared.

Three types of longitudinal transects are usually used when surveying an area:

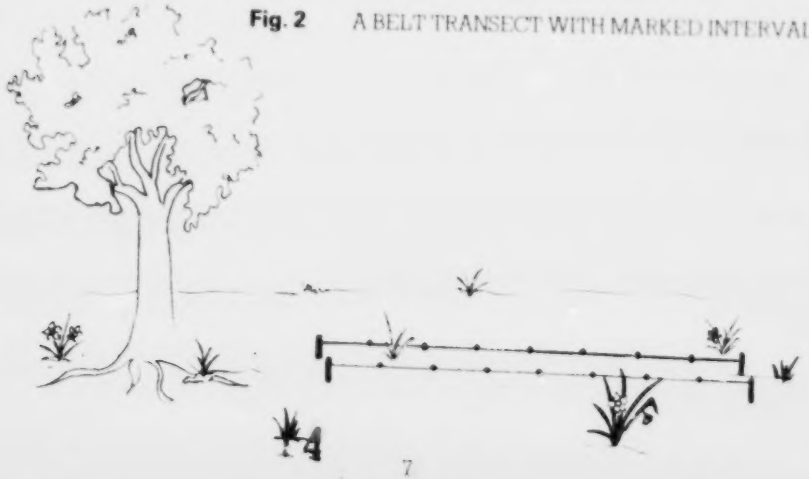
(1) Line Transect - a single line through the area to be surveyed. It merely consists of recording the plants and animals which are present along or touching the line at regular intervals. The interval length will depend on the vegetation in the area, e.g., it may be as short as 3cm or as long as 1 metre.
Height is omitted in this type of transect.

Fig. 1 MAKING A LINE TRANSECT



(2) Belt Transect - two lines, a distance apart (usually one or two metres) and running parallel forming a strip or belt of land. The belt is then marked out in 1m (or 2m) sections, transforming the strip of land into a line of quadrats. The vegetation is now described in the same way as for a quadrat. The density, percentage cover and frequency of the species in each quadrat can be recorded, mapped and measured. Factors which affect the distribution of plants, such as pH, light, rainfall, etc., can also be determined for each quadrat. The results of this can be plotted.

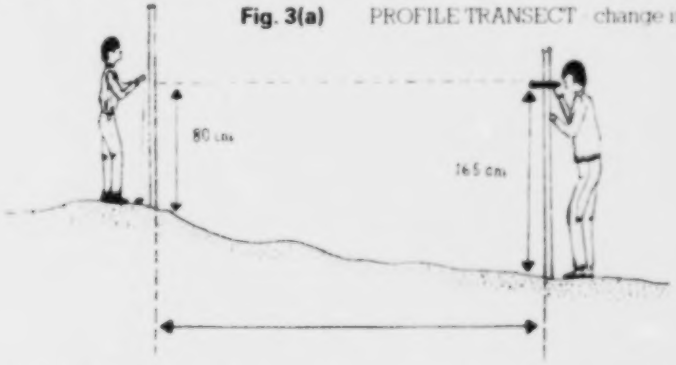
Fig. 2 A BELT TRANSECT WITH MARKED INTERVALS



(3) Profile Transect – this records the changes in plant distribution in relation to the changing altitude or levels of an area. Changes in vegetation height can also be recorded. If dealing with a short distance, changes in ground level can be noted simply by using a measuring tape and metre sticks. The intervals chosen depend on the vegetation, the gradient and the length of the transect.
For long transects both the change in level and the slope can be determined in the following way –

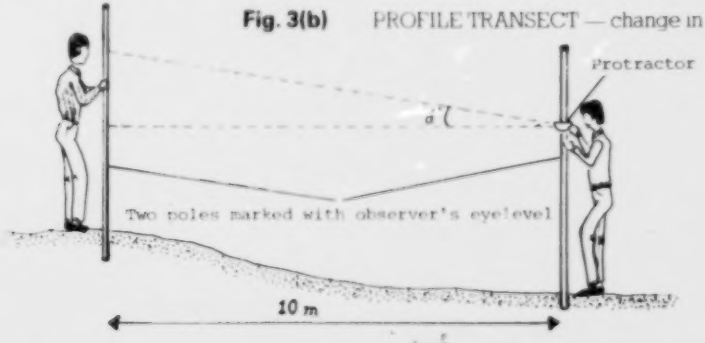
(a) Change in level – two long poles are placed together and marked with the observer's eyeline. They are then moved a known distance apart – never use a distance greater than 10 metres.
The observer then sights onto the second pole with a held level. Measure the two heights with a tape and calculate the difference in level.

Fig. 3(a) PROFILE TRANSECT – change in level



(b) Change in slope – the same two poles can be used (with the observer's eyelevel marked). They need to be 10 metres apart to measure the slope. A protractor is placed upside-down on the eyelevel mark of the first pole. The observer sights the eyelevel marks on the two poles (when placed apart) by adjusting the protractor, thus measuring the gradient.
The angle of the slope is calculated by subtracting the angle reading from 90°, i.e., if the angle reading is 79° then the gradient is 90° – 79° = 11°.

Fig. 3(b) PROFILE TRANSECT — change in angle



To record the vegetation present in all transects, a quadrat can be placed down on the ground at regular intervals marked in the transect. The most contrasting results are obtained if the transect is laid down in a marginal position, for example, from a lake up to a woodland habitat, from a bog to a heathland/woodland, from the centre to the edge of the woodland or from a shaded to an unshaded area.
The other factors cited earlier, i.e., pH etc. could be noted in conjunction with the vegetation records.

Quadrats

Quadrats can be constructed cheaply from clothes hangers. They can be made to your specific requirements in such cases. A quadrat, as its name implies, has four sides, is square in shape and made of wire, wood or string. A permanent quadrat can be constructed (from builders' twine and pegs) to show seasonal variations. This should be visited at least twice every season to record any changes. It can be any size, but it is best not to make it too large. A small quadrat measuring 25cm may be laid down in a permanent position using the pegs and the twine. The distribution of plants and ground cover may be recorded during the growing and the non-growing season.

Random Sampling

To sample a large area, it is best to choose a site randomly and construct a temporary quadrat, measuring 5m x 5m (using some suitable material as pegs). This quadrat is a good, manageable size and allows an accurate record to be made. A smaller quadrat (0.5m x 0.5m) is then thrown into this area over the shoulder. Wherever the smaller quadrat lands, the vegetation inside it is identified and given an abundance and a cover value. This quadrat is thrown into the larger area a number of times; this number depends on the similarity and uniformity of the vegetation within the area. Likewise the number of larger quadrats constructed depends on the similarity and the uniformity of the vegetation in the area. Usually ten to fifteen quadrats would suffice for a 20 acre area. If this method is not employed, the smaller portable quadrat can be thrown randomly over the shoulder into the habitat a number of times. This again depends on the similarity and the uniformity of the vegetation.
When recording the presence/absence of the vegetation, the following scales can be used:

ABUNDANCE SCALE	COVER	VALUE SCALE
Abundant	0%	5
Common	20%	4
Frequent	40%	3
Scarce	60%	2
Rare	80%	1
Absent	100%	0

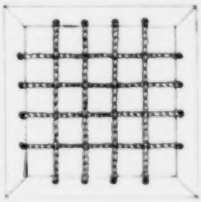
Abundance is used if numbers of individuals are not required; % cover is an index of dominance.

Non-Random Sampling

This method of sampling uses the quadrat and a line transect. When the line transect is laid down on the ground, the quadrat is placed at predetermined points on the line. These points can be at any intervals, e.g., 10cm to 3 metres, depending on your requirements.

Another type of quadrat which can be used in both these methods is a grid quadrat. A grid quadrat has an equal number of strings on two sides which form an area of smaller squares inside the quadrat.

Fig. 4 A GRID QUADRAT



Give a value to the plants present in each of the smaller squares.

This kind of quadrat is very useful when precise results are needed and accuracy is essential. Each small area becomes an individual quadrat and the plants present within these areas are given a value, i.e.,

A1 Clover 2%
A2 Clover 3%

and all the results are added to give the total value for the quadrat.

This type of quadrat is useful with students as they relate cover values, etc., better in smaller areas than a larger area.

A permanent quadrat may be constructed (from builders twine and pegs) to show seasonal variations. This should be visited at least twice every season to record any changes. It may be any size, but it is best not to make it too large. A small quadrat measuring 25cm may be laid down in a permanent position with the pegs and the twine. The distribution of the plants and bare ground may be recorded during the growing and the non-growing eason.

Mapping

It is often very useful to map the area to be surveyed. A map may be produced simply and quite easily. In the following method of baseline mapping, the list of equipment necessary is:

(1) 2 long pieces of string, marked at metre or ½ metre intervals;
(2) 1 tape measure;
(3) 3 garden canes;
(4) Compass;
(5) Graph paper and pencil.

The method is as follows:

(a) To form a baseline, lay the piece of string in the area you want to map with a garden cane at either end (x,y).
(b) The second piece of string is laid down at right-angles to the first piece, the third cane anchors the end of the string (x,z).
(c) To map a pond, you measure from the baseline at selected intervals to the edge of the pond and record the distance. Each position along the lines (x,y) and (x,z) is also recorded.
(d) A suitable scale is then chosen, e.g., 1cm = ½m and the baseline is drawn to scale on the paper.
(e) Plot the various points for the edge of the pond. When all the points have been plotted, draw the outline shape of it by joining all the points.

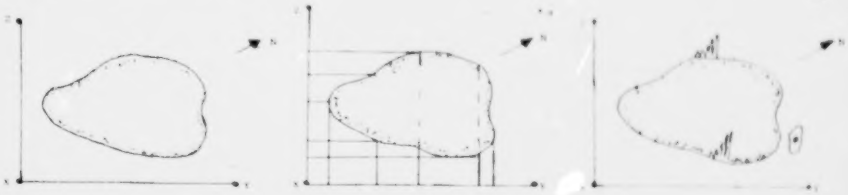
(f) Next, the other half of the pond has to be plotted so move the string (x,z) to a new location. This string is positioned at right angles to the original baseline (x,y) on the opposite side of the pond. Therefore the (z) cane becomes (a) and the new line is (y,a).

(g) Repeat the steps (c), (d), (e), marking the points to the edge of the pond from the new line (y,a).

(h) Any natural or artificial feature of interest may be plotted if it is located between the pond and the baseline. A symbol may be used to illustrate this feature; remember to note what each symbol signifies.

(i) Mark the direction of North (from the compass) on the map and on any map that you draw.

Fig. 5 SIMPLE MAPPING



Another method that may be used is Map Enlargement. In this method, the appropriate squares on the Ordnance Survey map of the area are enlarged onto a drawing sheet and the details are then filled in while out mapping the area. Maps of the local area are very helpful in this method.

Measuring Tree Height

The measurement of tree height may be performed in numerous ways, with different types of equipment.
The first method involves the use of an instrument called a Hypsometer - this is a simple, robust but expensive piece of equipment which includes instructions on its use.

The following three methods use inexpensive equipment and are not too difficult to perform.

(a) A length of timber - the exact length from the eyeball to the farthest stretch of the grasping finger and thumb - is needed. (This is constant for any one observer.)
The stick is then held in a vertical position by its middle.
The tree is aligned, using one eye and moving back and forth until the tip and the base of the tree are exactly in line with the upper and lower end of the stick.
A mark is placed on the ground at this point.
The height of the tree is now the precise distance from this mark to the centre of the tree at its base.
Measure the distance using a tape or by pacing (a pace is constant for any one observer).

(b) A ruler and a second person is needed for this method. The ruler is notched at the 3cm mark (on a 30cm ruler), and is held vertically at a fixed distance from the eye. The full stretch mentioned above is the easiest constant distance to use.
The tree is aligned so that it lies exactly between the 0cm and the 30cm marks on the ruler.

The second person stands by the tree and is guided (a little up, a little down, etc.) until a narrow piece of white paper is positioned exactly between the 0cm and the 3cm marks, i.e., in the notch, to the satisfaction of the observer.
This point is marked on the tree (A).

The height of this point above the ground, in centimetres, is the height of the tree in metres because it is 1/10 of the total height. (If an inch ruler is used, the notch should be 1 inch in length and the point on the tree is 1/12 of the total height.)
Figure 6b shows this second method of tree measurement.

Fig. 6(a)

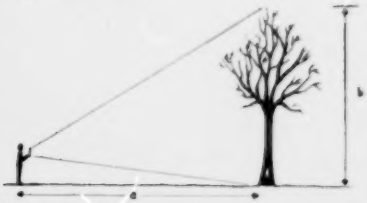


Fig. 6(b)

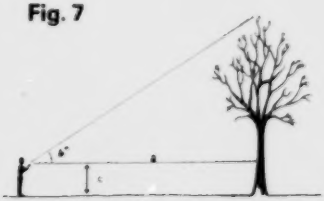
(c) Measurement by angle - In this method, a Clinometer is used (Fig. 7). The observer moves back from the tree until the tree is aligned. The observer sights onto the tree with the clinometer at 90° and records this height (C).
The observer moves back from the tree, aligning the tip of it with the clinometer until the angle is 45°. (If it is possible, measure to 45° as this simplifies the calculation because the tan of 45° is 1). To calculate the height, use the following formula:

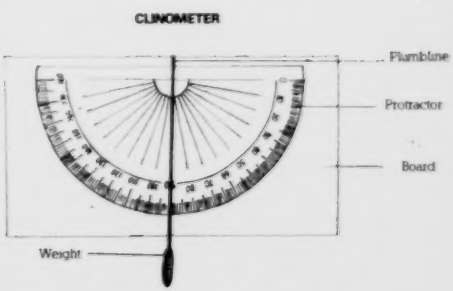
$$c + (a \times \tan b^\circ)$$

where c = eye height
where a = distance to the observer
where b° = angle recorded from clinometer.

Figure 7 shows this method.

Fig. 7





Environmental Factors

Environmental factors play a very important role in every habitat. They influence the type and luxuriance of plant growth in the area. They also affect the type of animals found in an area. There are some suggestions listed below for measuring various factors.

Light Measurement

Light is important to plants - they need it to produce food(photosynthesis). Some plants by adaptation may tolerate lower light intensities than others.

Light can be measured by two different methods using either (1) a lightmeter or (2) a light integrator.

(1) A Lightmeter: these vary considerably in price and complexity, ranging from the inexpensive photographic lightmeters to the expensive scientific types. Both give accurate light readings and may be used in a range of habitats.
A scientific model includes the Megatron Luxmeter, type DA 10 Mark 11, which may be adjusted to suit various light intensities. The light reading in this case is given in Lux.

(2) A Light Integrator. This is a simply constructed piece of apparatus, giving accurate light readings for a 24 hour period.
Figure 8 shows the method of construction. (Friend, 1961)

Fig. 8

EXPLODED VIEW
OF LIGHT INTEGRATOR

Top of Petridish
Black paper with a 10mm x 10mm hole
Fifteen sheets of Diazo Light Sensitive paper
Black paper
Foam
Base of petridish

The Diazo Paper (which can be obtained from an architects office) is cut to fit into the Petri-dish. Fifteen sheets are stapled together (use more than fifteen if you think it necessary, but never less) and placed between the two pieces of black paper, the top one of which has a hole 10 mm X 10mm cut in it to allow the light to penetrate this area and come in contact with the Diazo Paper.

The Diazo Paper is originally yellow and is very light sensitive. For this reason, the preparation of these integrators needs to be performed in a dark room. They also need to be taken to their location in a black bag.

Leave these light integrators in the selected positions for 24 hours, after which time they are collected and returned to the laboratory. They are transported there in a black bag (a refuse bag) to prevent further exposure.

In the laboratory, remove the Daizo Paper from the dishes in a dark room.

All the stapled sheets of paper are placed in a piece of muslin (or similar material) in a fume cupboard. They should be suspended over a container of ammonium hydroxide for approximately 10 minutes. When they are exposed to the vapour of this chemical, a reaction occurs which turns the white area black. Record the number of sheets which show this reaction.
The light intensity may be written as a % by expressing the number of black pages out of the total number of pages used, e.g., if ten pages were exposed for a certain location, then the light intensity for that area is:
10/15 X 100 = 66% LIGHT INTENSITY OR LIGHT PENETRATION HITTING THAT SPOT.

Humidity

Humidity, which allows growth of plants, usually ferns and mosses, in an area, especially on trees and rocks, can be recorded in two ways.

Both methods use a Hygrometer, however, one is stationary while the other has to be made move.

The first hygrometer may be contained in a weather station which would include other atmospheric recording instruments. The hygrometer itself consists of a wet and dry bulb thermometer which should be well ventilated; make sure that the wick is kept constantly wet and that its water supply does not dry out.

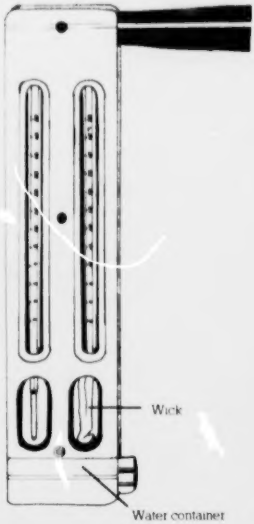
Fig. 9 Wet and dry bulb thermometer for measuring temperature and humidity

The second type of hygrometer is a Swirling Hygrometer, and, as its name implies, it has to be 'swirled' in the air to record the humidity accurately. It again consists of a wet and dry bulb thermometer which are connected to a handle. This allows it to be swung in the air at any level in a similar fashion to a football rachet.
Figure 10 shows a swirling hygrometer.

Once the 'dry and wet' temperatures have been recorded for an area, the relative humidity can be obtained by consulting the relevant tables. These usually accompany the instrument. A copy of the tables is shown in the back of this book.
(Relative Humidity is a measure of the amount of water vapour which the air contains compared to the amount it could contain.)

Fig. 10

SWIRLING HYGROMETER TO MEASURE HUMIDITY.



Temperature Recording

This may be recorded on a daily, weekly, monthly or seasonal basis. A maximum-minimum (max.-min.) thermometer is an indicator of the fluctuating temperature in any area.

This thermometer, as its name implies, records the highest and the lowest temperature for any area during any length of time. The metal pegs inside the individual thermometers stay at the highest/lowest positions for that period of time. They are then re-set using a magnet to record the temperature during the next time period.

Dial maximum-minimum thermometers are cheaper than other kinds.
The lake temperature may also be recorded using a max.-min. thermometer. The temperature of the air and the lakes may be recorded with a single thermometer, but for more accurate results the max.-min. one is the best.

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Weather Station

The station contains the following instruments:

(1) a wet bulb thermometer.
(2) a max.-min. thermometer.
(3) a rainfall indicator.

Rainfall

This can be measured by collecting the rainfall in the area (with a container or a number of containers). The time scale depends on the records one wants to keep.
The amount of rainfall in different habitats may be recorded and compared (if one container is placed at each site).

Sampling Animals

Tullgren Funnel (Dry Extraction Method)

This is constructed from some basic equipment:

a beaker (partly filled with 70% alcohol),
a wire mesh (to hold the sample),
a 40 watt light bulb.

The sample (soil, humus, timber etc.) is placed on a wire mesh.
Place this in a funnel.
The light source is placed over the sample (See Figure 11).
Put the beaker under the funnel and any organisms present in the sample will move away from the light, down the funnel and fall into the alcohol. The apparatus is left in this position for 24-28 hours.
The beaker may be covered to prevent evaporation of the alcohol.
This method is usually used to extract various types of small anthropods for identification purposes.

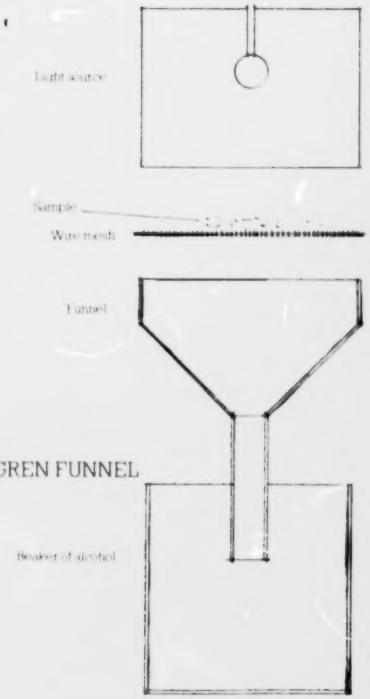

Fig. 11 AN EXPLODED VIEW OF THE TULLGREN FUNNEL

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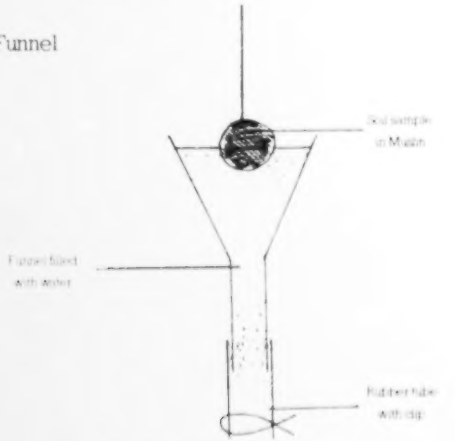
Baermann Funnel (Wet Extraction Method)

This has similar equipment to the first method, but uses water instead of light as its extraction mechanism.

A soil sample in some muslin is suspended in a funnel filled with water. The organisms present in the sample swim into the water and concentrate in the rubber tube at the funnel base.

Using a dropper, extract some water and examine this under the microscope. This technique is used to extract soil nematodes, soil oligochaetes (related to the earthworm). Figure 12 shows how to set up a Baermann Funnel.

Fig. 12 Baermann Funnel



Pitfall Traps

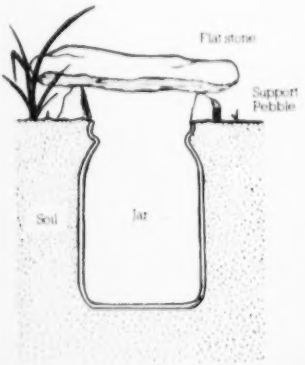
These are easily constructed with beakers or jars (any type of container can be used).

This method takes a few days to capture a substantial number of organisms (approx. ten). Ground fauna, spiders, beetles and insects usually find their way into the container.

If mammals are to be caught, then the trap needs to be baited with some flesh and left for a few days.

For quicker results, the sticky traps (such as those for catching flies in the home) may be placed on the ground. This, however, would only trap ground organisms.

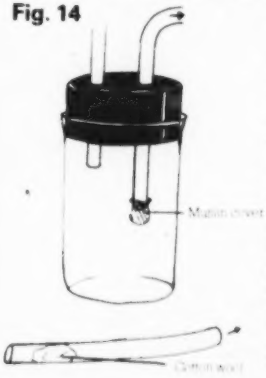
Fig. 13



PITFALL TRAP FOR ANIMALS

The best method is to handpick the organisms from the leaf litter or to use a Pooter. Figure 14 shows a standard and a home-made Pooter.

Fig. 14



Commercial Pooter (top) and homemade Pooter made from plastic tubing and cotton wool.
Suck in direction of arrow.

The home-made Pooter is made from a length of plastic tubing, one end of which contains a small piece of cotton wool. The animal is sucked up the tube and the cotton wool prevents it from being swallowed!!! It is then placed into a collecting bottle (which may or may not contain some alcohol).

A greater variety of animals may be collected in this way.

Some leaf litter can also be placed on a white tray (plastic butcher's tray), sorted out and the animals collected with the Pooter in this way.

Once collected, the organisms may be placed on these trays for identification.

Preserving Animals

Animals can be preserved in 70% alcohol or 5% formalin. These would include insects and other lower organisms.

However, certain organisms tend to lose their colour when put in this; others change shape entirely, e.g. slugs.

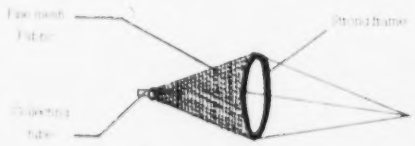
Nets

A variety of different nets are available for catching many types of animals. These include:-

(a) PLANKTON NET.

This is used to collect the microscopic life (plankton) in an aquatic habitat. It consists of a net which is made of a fine mesh fabric connected by a strong frame to a handle (which can be of any length).
A collecting filter or tube is attached to the end of the net. (Figure 15).
The net is swept along in the water a constant number of times in a certain time period, e.g. 7 sweeps in 6 minutes.
The sample in the tube can be returned to the laboratory for examination.

Fig. 15 PLANKTON NET



(b) SWEEP NET

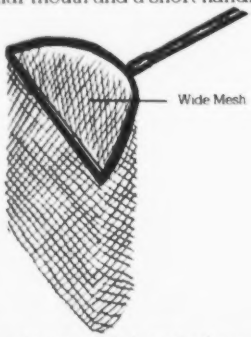
This is used to catch insects. It consists of a stout handle connected to a net with a wide mouth. (Figure 16) The net is swept through tall grass and other vegetation.

(c) BUTTERFLY NET

This, as its name implies, is used to catch butterflies and other flying insects. It has a wide triangular mouth and a short handle.

Fig. 16

SWEEP NET



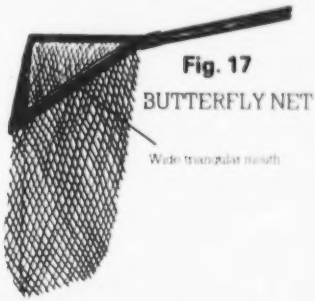


Fig. 17

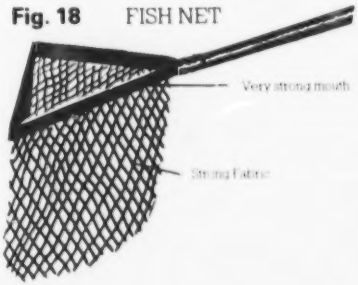
BUTTERFLY NET

(d) FISH NETS

These are used to catch fish and other aquatic organisms. The fish nets are made of strong fabric which can withstand water pressure and the weight of the fish netted. The net should also have a strong mouth to prevent breakage.

Water sampling nets may also be of the same strength, but may have a weaker fabric than the net.
Figure 18 shows a fish net.

Fig. 18 FISH NET



Pinning Animals

A collection of insects may be made for display purposes. However, one display per school will suffice as over-collection of animals deplenishes their numbers. This may lead to the extinction of animals.

Certain animals, such as beetles, butterflies and other arthropods, which can be displayed, should be pinned if possible. When they are captured, they should be put into a 'killing bottle'. Two types of 'killing bottle' can be constructed. The basic materials necessary for these include:

KILLING BOTTLE 1
a jar
some ethyl acetate
a piece of tissue
plaster of paris
cotton wool
a lid

KILLING BOTTLE 2
a jar
some ethyl acetate
filter paper
plaster of paris
cotton wool
short glass tube
a lid

For the first type of 'killing bottle' you pour the plaster into the bottom of the jar and allow it to dry. The ethyl acetate is added as the killing agent. A piece of tissue inside the jar prevents the insect from rolling around too much. The disadvantage with this system is

that the killing agent evaporates, and is difficult to replace.

The second type of 'killing bottle' consists of cotton wool soaked in ethyl acetate at the bottom of the jar. Some filter paper is placed on top of this and it is all covered with a layer of plaster of paris. A short glass tube is fitted into these two layers and reaches into the cotton wool. The advantage that this type of bottle has over the previous one is that the ethyl acetate can be replenished through the glass tube.

Alternatively, well decomposed Laurel leaves can be placed on the bottom of the jar. Some polystyrene board may be placed on top of the leaves and holes are punched in the board to allow the fumes to circulate. The tissues may still be used with this bottle. Figure 19 shows the general structure of the two killing jars.

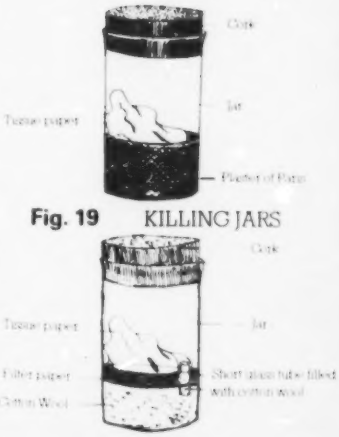
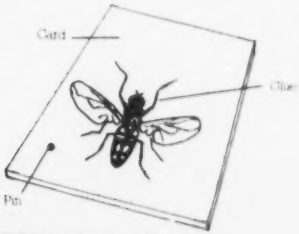


Fig. 19 KILLING JARS

Fig. 20



INSECT GLUED ON CARD

The equipment needed to pin the animals include:
entomological pins and pieces of triangular card, tweezers, moth proofer.
Once the animals are dead, they can be pinned. This can be performed in three ways:

(a) Put the insect on an individual card. Colourless glue is used to stick the insect on the card(See Fig. 20)

(b) The insect may be glued to the down turned tip of the triangular piece of paper (See Fig. 21)

Fig. 21

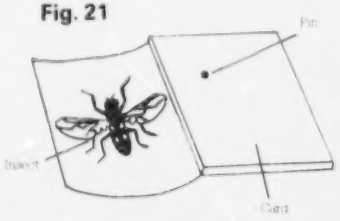
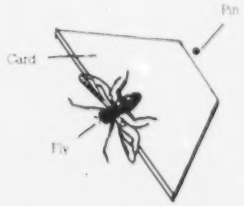


Fig. 22



FLY BALANCED ON END OF CARD

(c) An insect is finely balanced on the triangle card. (See Fig. 22.)

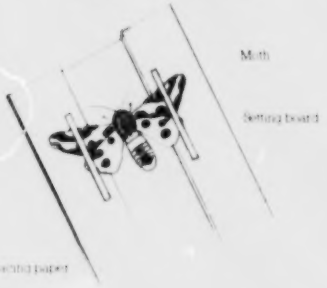
All these methods use colourless glue to stick the animal to a triangular card which is then pinned to the boards.

This second method pins the actual specimen. Moths, winged insects, etc., are set on a setting board.

The wings are pushed into position with a pin or a mounting needle and held in place with strips of tracing paper. (See Fig. 23)

Keep in a warm room. The insects should be dry enough to be removed from the board in about two weeks. Larger insects need longer to dry. When pinned, insects, in all cases, should be in a fresh and relaxed condition. The moth-proofer is used to prevent other organisms from surviving inside the display case and eating the preserved specimens.

Fig. 23 MOTH BEING PINNED ON SETTING BOARD



Plant Presses

Plant presses are available commercially. However, homemade presses are just as good. To make one, the following equipment is necessary:

(a) Two boards - measuring 0.5 metres square (50 x 50 cm)
(b) a heavy weight - a block
(c) newspapers to absorb the moisture.

Place the samples between the sheets of the paper and arrange them neatly. The sheets (with specimens) are then placed between the boards.
Apply the weight.
Leave for a few weeks.
Restack to stop mould growth.
When dry, remove the plants and stick them on some white paper with glue or similar adhesive material.
Add the collector's name and determination label to the paper.

Handlens

These are small magnifying glasses which can fit into the pocket. Their magnification ranges are usually small - but they may be used outdoors. This reduces the amount of collection and they should be taken along for this reason.

Binoculars

These are necessary to observe birds or other animals which are far away.
(Quietness is essential in all cases for observation.)

Microscopes

Light power microscopes are usually used to examine microscopic organisms on slides. Therefore, a binocular microscope is of greater use when examining larger plants, insects and other animals. When viewing these organisms be ready for some surprises!!!

Recording

It is best, when you know the investigations that you are to perform, to have record sheets prepared. This saves time, allowing the records to be made quickly and easily. Consult the examples of record sheets shown throughout this booklet. However, a note-book should always be brought along to record an unexpected discovery.

All recordings should be made in pencil as biro records are removable by rain!!!

Collecting Bags and Labelling

Collecting bags (the polythene freezer bags will do) come in a variety of sizes and the type of sampling to be performed dictates the bag size. All bags should be labelled clearly (See Labelling) either inside or outside. Self adhesive labels on the outside are the best for sampled material which contains moisture. Pieces of paper may be placed inside if the sampled material is dry.

Collecting bottles are plastic bottles which vary in size, the size is again dependent on the sampling that is to be performed. Adequate numbers of them should always be carried.

REMEMBER: over collection of any plant or animal is dangerous to that organism - so choose carefully and take only a few samples!

Labelling

It is very important to label the samples taken correctly as accurate recording is one of the keys of success in field studies.

Self adhesive labels should be placed on the outside of the various containers to be used. Ink and marker will dissolve, wiping away the record of the date and locality for the sample. As it is very frustrating when you return to work with the sample after the field trip, and the labels are in this condition, use pencil or indelible ink.

When you are in the field, the following information should be placed on the label:

(1) Date

(2) Locality

(3) Collector

For more permanent labelling, the following information needs to be recorded:

(1) Date

(2) Grid Reference (from Ordnance Survey map)

(3) Locality (common name)

(4) Collector (abbreviated to Coll.)

The label will look like this:

5/8/85

V 72 89

Wood near Cappanalea Lake

Coll. T. Murphy

Back at the Centre or the laboratory, when the material has been identified, a 'determination label' is applied. This includes the following information:

(1) Species' scientific name

(2) English name

(3) Person who identified it

(4) Date it was identified.

The label would appear as follows:

Digitalis purpurea. Foxglove

T. Murphy

7/8/85

If possible, a drawing pen with Indian Ink should be used. If this is not available pencil is adequate.

29

WOODLAND HABITAT

At an altitude of 400 feet above sea level, a natural woodland may be composed of many different tree species - these can include Birch **(Betula pubescens)**, Sessile Oak **(Quercus petraea)**, Ash **(Fraxinus excellsior)**, Mountain Ash **(Sorbus aucuparia)**, Hazel **(Corylus avellana)** and Willow **(Salix alba)**.

In the southwest, the dominant tree species are usually Oak and Birch Many woods may have Birch in the canopy, with the Oak trees in the lower strata. However, in this country, the Oak is the climax vegetation in most natural woods, particularly in the southwest. This process of change in any habitat is termed SUCCESSION. Succession is the predictable, gradual change through time, in the composition of plant and animal communities at a site, leading to the development of a climax community. The climax community in the south west is the sessile Oak with its associated plant and animal communities. The trees in such woods are generally small in stature due to the poor shallow soils and high altitude. Each habitat is divided into different layers or strata. The stratification of the woodland habitat is determined by height. The woodland is organised as follows:

Ground Layer - mosses, small ferns (up to 5cm high).
Field Layer - bracken, woodrush, (up to 1m high).
Shrub Layer - saplings - Holly (Ilex aquifolium), Hazel, Birch (1 to 3m high).
Canopy Layer - Oak (Over 3m high).

The abundance of ferns and mosses **(Bryophtes)** is a result of the warm moist climatic conditions and, to a lesser extent the acidic nature of the soil. The most common fern throughout such areas is the bracken fern **(Pteridium aquilinium)**.

'Dryopteris' with their triangular shaped, narrow and finely dissected leaves are the most conspicuous of all the ferns on the woodland floor. Species present include the male fern **(D. felix-mas)** and the lady fern **(D. felix-femina)** which produce many fronds from the one point.

Fig. 24

DRYOPTERIS FERNS AS SEEN ON THE WOODLAND FLOOR

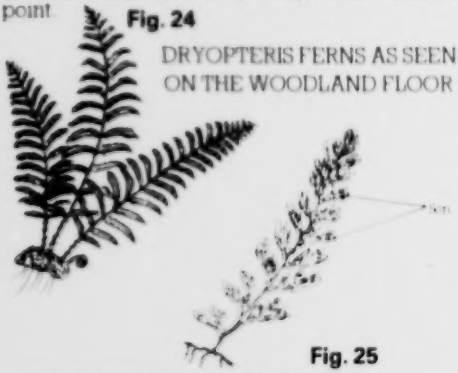


Fig. 25

FILMY FERN **(Hymenophyllum)** frond with spore containers (sori)

Other ferns found in the woodland are the hard fern **(Blechnum spicant)**, and the common polypody **(Polypodium vulgare)**. Some of these ferns can be found in the field layer or growing on the outer surface of trees. They are then classified as epiphytes. Epiphytes include mosses, ferns, lichens and other plants which use this method to gain extra light. Certain ferns are rarely found growing on the ground but prefer to compete as epiphytes eg. the common polypody.

A fern of particular interest in woods of the southwest is the filmy fern(Hymenophyllum). This species derives its name from the thin translucent fronds which are only a few centimetres long. This fern is particularly susceptible to dessication and is generally found in damp, shaded conditions growing with a selection of mosses.

Another plant of interest is the liverwort, **(Pellia species)** (Fig. 26.) which is located in very wet areas. It is most abundant along streams in woodlands. The plant **(thallus)** is dark green in colour and is shaped like a liver. The fruiting body **(sporophyte)** is produced in October/November - this consists of a jelly-like, almost transparent, stalk which is topped with a black capsule. This is raised above the thallus when the spores are ripe. In the capsule, after dispersal, the spore develops into a new thallus **(gametophyte)** in favourable conditions.

Fig. 26

Thallus of Liverwort, **Pellia** species, showing sporophytes on a long jelly-like stalk.

The abundance and profusion of these bryophytes is evidence of the high humidity of the woods in the southwest. Such plants cannot survive in drier areas because water plays a central role in their reproductive processes. It is interesting to note, that even in hot summers the mosses in such areas can produce the sporophyte (capsule) which contains their spores. Most mosses have distinctively shaped capsules useful in identification and these should be noted. (Fig. 27). Foreign ecologists who visit such areas are always amazed by the phenomenal growth of bryophytes, which shouldn't be damaged.

Fig. 27

Notice the different types of capsules (fruiting bodies) of different moss plants. These can aid in identification.

The high humidity also allows a luxuriant growth of epiphytes - these include the common polypody; a variety of mosses; lichens such as oak moss, **(Evernia prunastri),** and old man's beard **(Usnea subfloridana);** ivy **(Hedera helix),** and woodbine **(Lonicera periclymenum).** If hollows are present in the tree or if the bark splits, flowering plants such as violets **(Viola)** may take root and grow there.

All plants need light to make food. Certain plants such as the epiphytes have adapted in a special way so that they gain maximum light. Some plants can tolerate shade conditions better than others. Most of the flowering plants produce their flowers early in the year before the full canopy of leaves appear. This enables them to use the remainder of the growing season to build up food stores for the winter. Woodland plants like wood sorrel **(Oxalis acetosella),** bluebells **(Endymion non-scriptus),** lesser celandines **(Ranunculus ficaria),** and wood anemones **(Anemone nemoros)** all possess swollen food storage organs such as tubers and bulbs.

The reproductive cycles of these plants in the ground layer is greatly influenced by seasonality and the amount of light reaching them.

Seasonality

Activity in any habitat is determined by the seasons. As seasons change, so too does the climate of the area. In winter, the activity of plants and animals is very low due mainly to the low temperatures, high rainfall and high humidity. Indeed, at this altitude, the temperature can drop to as low as -5°C and weekly rainfall may be as high as 90cc. The soil is, therefore, too cold and is not ideal for growth.

As spring approaches, the temperature increases while the rainfall and humidity drop considerably. For example, the temperature can rise up to 10°C, humidity can decrease to 30% while rainfall drops to 60cc or less. Many plants, including the trees, begin to produce leaf buds (which are protected from extremes of weather by resin, etc.) while many mosses produce their sporophytes.

As the season progresses into March, many of the ground layer woodland plants begin to flower giving a new life to the area. Plants such as the lesser celandine produce their yellow, star-shaped flowers, protruding from the mosaic of glossy, oval leaves. It continues to flower until May. As insect pollination cannot be relied upon at this time of year, this plant produces special tubers which fall from the leaf axils in June. This occurs simultaneously with the shedding of leaves giving rise to a new plant.

The wood anemone also flowers as early as March, producing white flowers at the end of a long stalk. The aerial parts usually wither after the trees have come into leaf. These also reproduce using a rhizome (an underground stem), which allows them to carpet the area very quickly. The wood sorrel with its clover-like leaves produces its flowers from April to May. The flowers are white, marked with red veins. This plant is usually found in shaded conditions as it cannot tolerate direct sunlight. The sweet violet **(Viola odorata)** flowers in March or April. It produces sweet smelling, dark violet flowers together with the leaves, directly from the rhizome.

As spring progresses, plants such as bluebells appear, carpeting the ground with a mass of blue flowers. Other plants to bloom in May include cow wheat **(Melampyrum pratense),** a small plant with yellow flowers scattered along the stem. Goldenrod **(Solidago virgaurea),** bearing spikes of bright yellow flowers and herb robert **(Geranium robertianum),** with its reddish-purple flowers all bloom at this time of year.

At this time, the oak produces catkins, followed by leaves at the end of May. (A catkin is an inflorescence of male or female flowers). In this way the pollination and reproductive process is unhampered. Birch follows a similar pattern, although it produces catkins earlier.

In June, the trees have a full canopy of leaves, which give condiderable shade to the lower plants. Temperature has increased considerably, probably as high as 24°C while humidity can remain static or increase slightly to 34%. Rainfall levels have dropped to as little as 10cc, or less in dry summers. It is the distribution of the rainfall between the seasons, and not the quantity, that is important to the continued existence of the woodland.

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As the summer months proceed, humidity will drop to less than 10% while temperature may continue to increase. Plants flourishing under these conditions include the bracken fern which can grow to a height of 2 metres. The foxglove **(Digitalis purpurea)**, producing a long stalk, can attain a height of 1 metre. It is topped with solitary, showy, nodding red flowers darkly spotted inside. The various heathers **(Calluna vulgaris** and **Erica tetralix)** present in the woods at high altitude also bloom at this time of year.

Woodrush **(Luzula sylvatica)** and bilberry **(Vaccinium myrtillus)**, produce flower-heads during June and keep them until August.

The Holly in the shrub layer is an evergreen - it loses only a small number of leaves throughout the year (unlike the deciduous trees which lose almost all their leaves together). It produces its pinky-white flowers in June.

As autumn approaches, the humidity and rainfall increase while the temperature drops slightly. The changing colours of the leaves and the production of fruits herald the coming of winter. The seeds are formed so that plants can regenerate themselves in the coming year while fruits are produced to protect and nourish the seed. It also is food for the vector. (A vector is an animal such as a bird which unknowingly transports the seed to a different area from the parent.)

Autumn conditions allow the growth of fungi and the production of sporophytes by liverworts and mosses. As winter approaches, activity gradually begins to decrease and the area remains in a dormant-like state until the following spring.

VARIETY OF PLANTS

The slighty acidic nature of the soil and poor drainage contribute to the paucity of flowering plants in the woods. This is particularly apparent if a lowland wood on a deeper soil is visited.

Plants that grow under acidic conditions are examples of **calcifuges** - they are fugitives from calcium (lime or alkaline soils). Such plants indicate acidic conditions in a soil and include the Greater Woodrush with its tussocks of bright green leaves.

Fungi

The increased rainfall during September and October accompanied by high humidity and relatively high temperatures allow the fruiting of a multitude of fungi in various locations. Fungi play an important role in decomposition and nutrient recycling. Mushrooms and toadstools, also known as gill fungi, produce large fruiting bodies consisting of a cap, gills and stalk. Undoubtedly, the most conspicuous of the toadstools present is the fly agaric **(Amanita muscaria)** which produces a red cap with white scales attached to it. This is the toadstool which is often seen on the front of cards accompanied by leprechauns, fairies and other such creatures. It is quite large, producing a cap up to 20cm across.

Other gill fungi include the brown roll-rim **(Paxillus involutus)**, which is about 10cm across, the cap of which has a rust brown appearance at first, turning hazel or snuff brown later. Many gill fungi attack living trees. One example is the honey fungus **(Armillaria mellea)**, also known as the 'bootlace' fungus because of the long black cords which can be found under the bark of infected trees. It also produces olive or yellow coloured fruiting bodies at the base of infected trees.

Boletus species are unusual in that instead of gills, their underside is perforated with pores. The spores are liberated through these pores for example in **Boletus porosporus** with its olive brown cap. The bitter bolete **(Tylopilus felleus)** with a snuff-brown cap is another example. The hedgehog fungus **(Hydnum repandum)** is recognised by the creamy white colour and the presence of soft spines, instead of gills, under the cap.

Another group of fungi on trees is known as Bracket fungi, since they appear like brackets on their host. They tend to appear throughout the year and possess pores instead of gills. The most common here is the birch polypore **(Piptoporous betulinus).** However, the many-zoned polypore **(Coriolus versicolor)** may also be found here.

The birch polypore produces a kidney shaped, creamy-white fruiting body, up to 20cm across. It can be found on living or dead trees. If it grows on living tissue it is called a parasite. However, as a saprophyte it may appear in great numbers on the tree trunk where it causes white rot resulting in the death of the tree. They can grow to be quite large, both in diameter and thickness. They usually attack Birch but can also be found on Oak. The many-zoned polypore is much smaller in size. It is usually found on dead stumps. A number of these is seen lying under each other (attached to the trunk). The species derives its name from the fact that the fruiting bodies are highly variable in colour and each colour band is called a 'zone'.

Some really strange looking fungi can be found on dead twigs and other decaying matter. These include the unusual, yellow brain fungus **(Tremella mesenterica),** which has a strange velvety texture as well as soft, flabby, gelatinous lobes and folds which are golden yellow to orange. The distinctively named jew's ears **(Auricularia auricula-judae),** which has a gelatinous fruiting body and is tan brown in colour and ear-shaped, becomes hard and horny when dry.

A whole variety of fungi is to be found on decaying timber. These include the green wood-cup **(Chlorosplenium aeruginascens)** which produces 'green oak'. The mycelium growing through the wood stain is blue-green in colour. As the name implies, it is usually found in dead Oak. In the past, this used to be incorporated in frames for pictures. Black spot-like structures may also be found both inside and outside the bark - this is a fungus called **Diatrype disciformis.** Another unusual looking fungus is the candle snuff fungus **(Xylaria hypoxylon),** which produces a black and white antler-shaped fruiting body.

The common earth-ball **(Scleroderma citrinum)** is seen on the ground near heathland or in woodland from September to November. It bursts periodically, with the help of raindrops or animals, to liberate spores.

A word of warning here, NO FUNGUS SHOULD BE EATEN UNTIL ITS IDENTITY AND EDIBILITY HAS BEEN CONFIRMED EITHER BY AN EXPERT OR FROM VARIOUS TEXTS. (A book by Phillips 'Mushrooms and Toadstools in Great Britain and Europe' can be used for this purpose).

The fungi described here are only a small number of those found in any woodland, so keep your eyes open, particularly in autumn/early winter. Other decomposer plants are seen growing with the fungi. These include the slime moulds **(Myxomyctes species)** with yellow, red and black fruiting bodies. Slime Moulds can take a variety of shapes. They are very small and usually it is the fruiting bodies that are recognised.

Plantations

Much of the land surrounding natural woods at this altitude has recently (within the last 60 years) been planted with 'commercial' trees. These plantations are usually monocultural (one type of tree species), e.g., Sitka Spruce. The trees which are planted will be used, when fully mature, for a variety of purposes such as telegraph poles. As they grow to this stage, the trees can be felled (cut down) and used for woodpulp, etc.

Firstly, these woodlands are managed by man and are grown to meet his demands for economic reasons.

Secondly, their structure is in total contrast to the natural woodland.

This habitat usually possesses only two strata -

(1) The ground layer and

(2) The canopy layer.

The ground layer vegetation (mosses, brambles, some ferns and grasses) is very sparse due mainly to low light intensity and changes in soil acidity as a result of the trees needles. Because of this poor level of vegetation, animal life is not very diverse and numbers of species are low.

In recent years, the regularity of forestry plantations has been changed as foresters have become more aware of the plantations' effect on the landscape. Irregular edges are now present to give them a natural appearance and other trees such as Firs and Birches are also planted to add variety to the area. These species should improve the diversity of plant and animal life in these areas. However, in many plantations where clearings are present, the more natural type of plantlife and stratified layers can be seen.

Animals In Natural Woodlands

The animals found in the wood are present in three main regions. These are:

(1) the leaf litter, etc.;

(2) the soil;

(3) the air.

They are constantly present in these regions and can only be found by active searching and looking.

Both the soil and the leaf litter regions are inhabited by similar creatures, but the former tends to have lower numbers present, probably due to the compact nature of the substratum. For this reason, it is best to start with the leaf litter.

The invertebrates include a variety of forms and sizes; they can be found by searching under stones, hand-sorting the leaf litter and examining decaying tree trunks. Other extraction techniques can also be used. (See Techniques section).

It is not possible to describe all the organisms found in any of the regions here; selected guides from the Bibliography with diagrams and keys will perform this function. Some of the more common ones will be described. A simple key will be given so that these animals can be easily identified.

Leaf Litter

This is an area rich in food and is composed mostly of dead leaves, but with some bark, branches and fruit. As well as a food source, it is used as a breeding area and it is quite likely that you will find eggs, larvae and nymphs with the adults.

Whatever the mode of existence, all are well adapted to their way of life. For instance, some produce special cellulases to help the digestion of cellulose, others have bacteria and protozans in their stomach to aid their digestion.

Probably one of the more common of the tiny insects found in this region is the springtail. These insects **(Collembola)** live mainly on soil fungi and decaying organic matter. Their name is connected with their mode of travel - they jump by folding back part of their abdomen under themselves and when it is released like a pogostick, they spring huge distances relative to their size. (Fig. 29.)

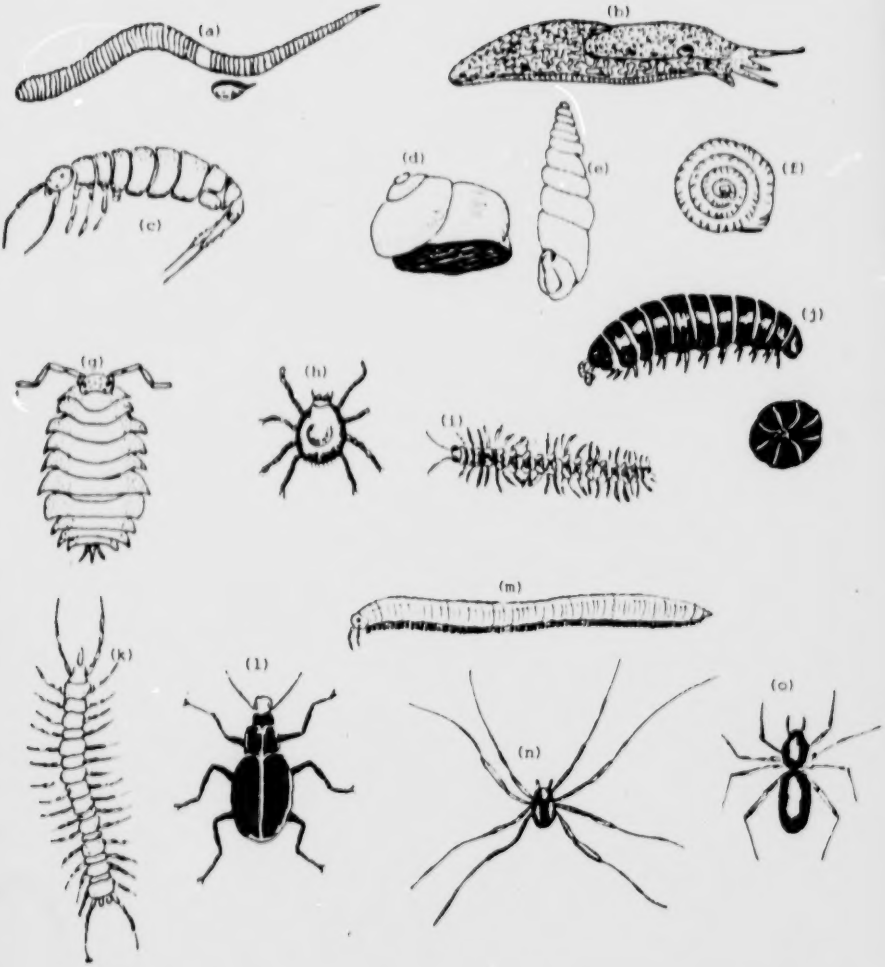

Fig. 29
(a) Earthworm with cocoon (up to 10cm long); (b) slug (up to 10cm); (c) Springtail (up to 5mm); (d, e and f) Land snails (up to 15mm); (g) Woodlouse (1cm); (h) Mite (2mm); (i) Millepede (30mm); (j) Pill Millipede (up to 30mm); (k) Centipede (up to 50mm); (l) Ground beetle (10mm); (m) millepede (up to 15mm); (n) Harvestman (25mm); (o) Spider (up to 15mm).

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Woodpigs or woodlice **(Isopoda)** are also very common in the leaf litter. These animals resemble tanks on the move as their bodies are covered with a series of plates.

Ticks and mites **(Acarina)** feature among other animals found in high numbers in the leaf litter. These are often pests and are parasites of animals. Larger animals include the centipede **(Chilopoda species)**, which is a fast moving carnivore (meat-eater) and the slighty smaller herbivore (plant eater), the millipede **(Diplopoda species)**.

A number of these animals, particularly the woodlice and springtails, play an important role in the decomposition of the leaf litter.

Soil

The number of these animals present in the soil (to a depth of 10cm) relative to the leaf litter is greatly reduced, due mainly to the restrictions on movement. The only animal found here in great abundance is the earthworm **(Lumbricus terrestris)**. This animal plays an important role in the ecosystem - breaking down dead organic matter (leaves, etc.) into humus, mixing this and enriching the soil.

The Air

Animals in the third region include birds **(Aves)**, and the flying insects and mammals. Firstly, the birds here include the woodpigeon **(Columba palumbus)**, bluetit **(Parus caeruleus)**, chaffinch **(Fringilla coelebes)**, robin **(Erithacus rubecula)**, and many others. These are best observed alone or in small groups using binoculars (8 x 30 to 10 x 50). Quietness is essential.

Bats (the only flying mammals) are to be seen at dusk. Evidence of their presence is a strong but wavering flight pattern against the darkening sky. Listen carefully. Most people can just detect the near audible pops at one or two second intervals. This is used as radar to help the bat catch insects and avoid large obstacles in their path.

Insects can be seen during the day and night and many of these are both fliers and biters, as you will soon discover should you enter the woodland during the summer or early autumn. Such a prospect should not deter any field studies student from entering a habitat! Insects as disease vectors for malaria, are absent from this country. The bite itself which may cause irritation can be relieved with a rub of antihistamine ointment ("Anthisan"). Sprays tend to be more effective than ointments as insect repellants. The major "avaricious" offenders are described below.

Diptera are an order of flying insects commonly known as flies. They have two pairs of wings, the third pair is modified to help in their flight.

(1) MIDGES (not Midgets)
These are insects belonging to the order **Diptera**, family **Ceratipogonidae**. They are tiny flies that bite in swarms, especially as the sun goes down on moist days. To my knowledge, there are no midgets (dwarf humans) who practice this habit. They can be identified by their small size and the dark bands on their wings.

(2) MOSQUITOES (10-20mm)
These, too, belong to the order **Diptera**, but in the family **Culicidae**. They are longer (about 20 times) than midges and lack the dark bands of their wings. They possess long sucking mouthparts, well adapted to their biting habit. Their larval life is spent in freshwater - they can be found in large numbers in animal drink troughs and in trapped water in the basal leaves of woodrush **(Luzula sylvatica)** or field woodrush **(L. campestris)**.

HORSEFLIES or CLEGS.
Still in the order **Diptera,** belonging to the family **Tabanidae.** They are also called 'doctors'. These are quite large (about the size of a bluebottle) and have sawing mandibles which they use to cut a small wound from which they take blood. Some horseflies possess fabulously coloured striped eyes, well worth investigating with a handlens. They bite on sunny days either outside the woodland or along its margins.

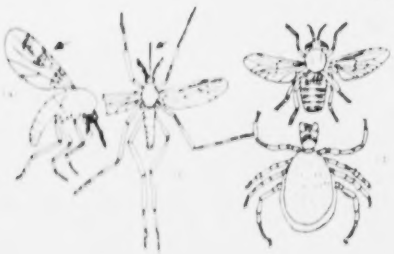
Ticks and Sciortans

These are not insects, they are **Arachnids.** They don't possess the power of flight.
Sheep ticks **(Ixodes ricinus)** are the most common. They are easily recognised and the small larva (stage after the egg hatches, young of the animal) looks like an immature adult with three pairs of legs. Adults and nymphs (minature copy of the adult) all possess four pairs of legs. Best removed from humans by placing a drop of methylated spirits on the attached tick which causes the mouthparts to contract, allowing the tick to be removed easily and cleanly. If it is pulled away without applying the spirits, the mouthparts may remain attached, causing a local infection.

Galls

A gall is the result of an attack by an insect on a plant. The gall itself is formed by the plant in response to the laying of the eggs by the female in that plant.
Galls can be found on any plant but the Oak may possess two or more types and is a good example of a host plant.

Fig. 27 BITING ARTHROPODS
(a) Midge, (b) Mosquito, (c) Horsefly, (d) Tick.



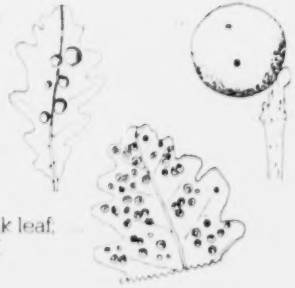


Fig. 28

GALLS
Three examples of galls on oak - (a) marble gall on oak leaf, (b) oak apple gall on twig, (c) spangle gall on oak leaf.

The galls are caused by a number of species of gall wasp. Each species has a slightly different life cycle but basically the reaction of the plant is the same in all cases. The female wasp lays eggs on the branches of the tree. As the larva develops, the plant tissue

responds by growing into the characteristic gall. It provides the larva with food and shelter as it passes through the egg-larva-pupa development. The young adult wasp bores a hole in the gall to release itself. A gall with a hole means that the adult has emerged. The cycle is repeated continually but its duration varies with the species of wasp.

Vertebrates

Vertebrate signs include droppings, footprints, scents, hairs, grazing or antler marks on trees. Faeces of animals can be particularly interesting and show the diet of the animal.

For example, fox's faeces may often contain rabbit hair and bone; bird droppings may be strange colours – a green-like mess is probably the faeces of a woodpigeon whose diet consisted of ivy berries. These are very dependent on the colour of the food consumed, so unusual colours may be seen.

Owl pellets may also be found. These are the remains of the prey, formed into a pellet and regurgitated. If they are disintegrated, the skeleton of the victim can be reformed. This can then be identified using the appropriate guide.

Mammals

While travelling through the woods quietly, and on your own, it is quite possible that some field mice **(Microtus agretis)** and some shrews **(Sorex species)** may appear. Bigger mammals such as foxes **(Vulpes vulpes)**, badgers **(Meles meles)**, rabbits **(Dryctolagus cuniculus)** and deer **(Cervus species)** may also be seen. These animals are quick to take flight, so you must be alert to spot them.

INVESTIGATION NO. 1 * Stratification In Woodland

Introduction

In the general account of a woodland, it is seen that the vegetation is divided vertically into different layers or strata. This division is based on height and termed stratification in a woodland habitat. Four strata exist and these are:-

(a) ground layer

(b) field layer

(c) shrub layer

(d) canopy layer

Figure 30 illustrates the appropriate positions of each stratum.

Fig. 30 WOODLAND STRUCTURE

In this investigation you will measure the height of each stratum and identify the main plants present.

Equipment

To determine the stratification in the woodland, the heights of the various strata need to be measured.
You will need:

(i) builders' twine
(ii) poles
(iii) measuring tape and
(iv) clinometer

40

Procedure

(1) Select an area in which each of the four strata can be easily distinguished, e.g., a clearing in the wood.

(2) Construct a profile transect, firstly along the ground layer. Position it so that the line touches the top of any vegetation present. (See Fig. 1). Record the distance between the ground level and the line.

(3) Construct a similar transect for the field layer and record the height.

(4) Measure the shrub layer using the clinometer. Select the highest of the tree species in this layer and use the technique outlined earlier.

(5) Measure, if possible, the dominant tree species using the clinometer. (This can be performed at the edge of the wood.)

In each layer, try to identify the main plant(s) present and record them.

Points For Discussion.

The dominant component of the system.

The influence of the climax community on the lower strata.

The pattern of growth in the lower strata.

INVESTIGATION NO. 2

* Description Of Plants In The Ground And In The Field Layers

Introduction

As an extension of the previous investigation, the lower layers of vegetation can be examined with greater accuracy using various sampling techniques. Such techniques can be used to describe any area.

The purpose of this investigation is to describe the spatial distribution (horizontal distribution) of the plants in the woodland habitat. Another objective of this is to become aware of the sampling methods and to be able to perform them in any habitat.

Random and non-random sampling techniques can be used to determine the quantity of vegetation present.

Equipment

To sample the area you will need:

(i) quadrats (0.5m x 0.5m)

(ii) measuring tape

(iii) notebook and pencil (or record sheets)

(iv) collecting bags and labels

(v) selected guides (see Bibliography)

Procedure

Random Sampling

To describe the area accurately, it is best to use the following method:

(1) Select areas in the wood at random and create quadrats measuring 5m x 5m using some sticks and builders' twine.
(2) Throw the smaller quadrats (0.5m x 0.5m) into this area and identify everything present in the smaller quadrat. (See Page 9)
(3) Give each item (plant, bare ground, dead material, etc.) an abundance value from the scale previously stated.
(4) A percentage (%) cover value can also be given. (See Techniques section). For % values, it is more accurate to use the quadrat with the string grid.
(5) The number of large quadrats taken depends on the size of the area to be sampled, for example, a wooded area of 20 acres should have ten large quadrats.
(6) The smaller quadrats are thrown into the larger areas a number of times, usually between five and ten times.

Non-Random Sampling

(1) A line transect and small quadrat are used in this method.
(2) Select an area in the wood, lay down a line (builders' twine) with marked intervals. These intervals can be at any distance - usually of 1 metre.
(3) Place the quadrat (0.5m x 0.5m) at the marked intervals and identify the various items present.
(4) Take a number (ten) of these line transects.

Some of the plants found in the ground layer include the wood anemone, wood buttercup, various mosses and wood sorrel.

In the field layers, bracken, fern, hard fern and woodrush may be found.

Results

Sheet 1 shows a typical record sheet. The following is a sample of results for the ground layer in a woodland habitat.

Quadrat No.		Species	Wood Sorrel	Goldenrod	Wood Anemone	Bluebell
1	Abundance		9	2	1	1
	% Cover			25	15	15
2	Abundance		5	1	1	
	% Cover		60	15	15	
3	Abundance		7			
	% Cover		20	25		

Points for Discussion

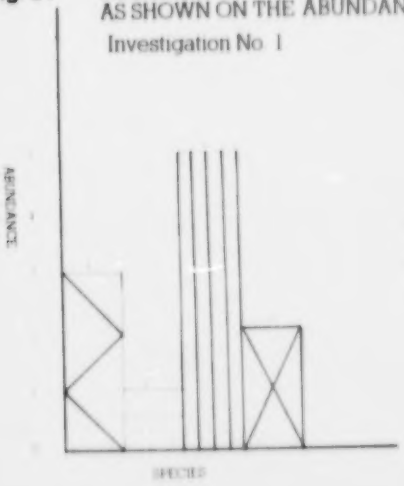
When all the results are tallied and analysed, try and draw some conclusions from the data. You may find the following headings useful. Feel free to add extra headings.

Similarity of vegetation
Abundance of plants in certain areas
Factors affecting distribution
Effect of grazing on the area

Graphs of abundance and % cover may be produced, i.e. these can include individual species or many species.

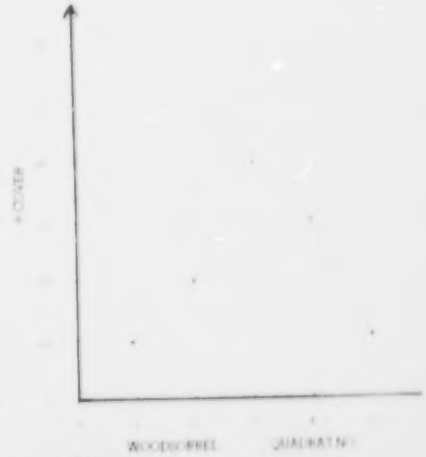
Fig. 31 ABUNDANCE OF 4 PLANT SPECIES AS SHOWN ON THE ABUNDANCE SCALE

Investigation No. 1



Investigation No. 2

Fig. 31(a)



INVESTIGATION NO. 3

* Relationships Between Plants, In Particular Epiphytes

Introduction

Many plants live in association with other plants. These relationships may be parasitic (growing on living material) or saprophytic (existing on dead material). Epiphytic (living on the surface of other plants) or symbiotic (a plant in a close relationship with another plant, both co-operating with each other to their mutual advantage) arrangements are also present in a woodland habitat.

In this investigation you will determine the plants which live as epiphytes. The vertical distribution pattern of these epiphytes may also be plotted. Epiphytes are usually found on the plants of the shrub and canopy layers, i.e. trees. When you have listed the plants that are epiphytes, categorise them into their respective groups, i.e.

lichens
mosses
ferns
flowering plants e.g. ivy, woodbine, etc.

Try to identify some of the lichens, ferns and flowering plants using appropriate guides. (Keep this record as it will assist in a later investigation.)

Equipment

List of equipment you need:

(i) A notebook (or record sheets) and pencil.

(ii) Collecting bags.

(iii) A compass, pen and a quadrat (10cm × 10cm).

(iv) Measuring tape.

(v) Selected guides (See Bibliography).

Procedure

(1) Select a number of trees from the shrub and canopy layers.
(2) Take 4 points, (north, south, east and west) at ground level, ½ metre, 1 metre and 2 metres.
(3) Mark each aspect (north, etc.) with a pin.
(4) Place the quadrat mid-way on the pin.
(5) Write down what type of epiphyte is present at each aspect.
If you are unsure of the plant, collect a small piece and identify it later. If there is no need to identify the mosses, collect a small piece and label it Moss A so that it is recognised on other trees.
(6) Epiphytes can be given a cover value.
The result sheet might appear as follows:

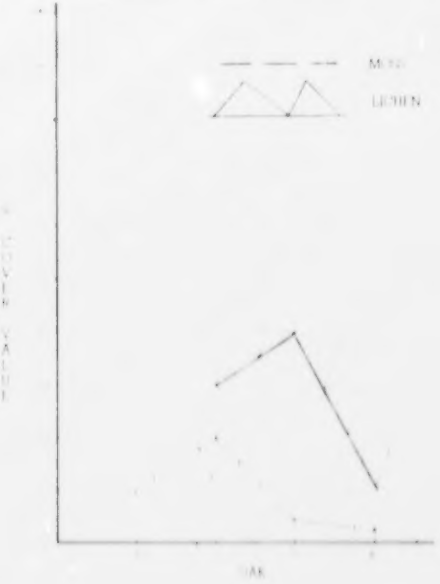
Results

Host Plant Species	Epiphyte	% Cover Value			
		N	S	E	W
Oak	Moss A	10	–	–	–
at ground level	Moss B	–	15	15	–
	Moss C	–	30	–	5
	Lichen				
	Old Man's Beard	–	15	60	20
	Oak Moss	1	20	15	30
	Ivy	15	20	–	25
	Bare Trunk	75	–	10	20

To analyse the results, produce some diagrams. Histograms, pie charts or other methods can be used. For example:

Investigation No. 3

Fig. 32



Points for Discussion

After the results are analysed, write your discussion under the following headings:

Abundance of epiphytes

The significance of aspect to lichen presence

The vertical distribution pattern of the epiphyte

Other factors influencing lichen abundance

INVESTIGATION NO. 4 * LIGHT PENETRATION IN A WOODLAND HABITAT

Introduction

Light penetration is very important to plants in any habitat as they require the correct intensity and quantity of light to make food (photosynthesis) and to regulate flowering.

In a deciduous woodland, the majority of flowering plants come into flower before the trees produce their leaves. This adaptation allows the plant to complete its life cycle before the amount of light reaching it is reduced. Light penetration can be studied with two types of lightmeter - one is expensive and fairly large, the other is inexpensive and small. In this investigation you will compare the light intensity of various areas and relate this to the ecological requirements of the different groups.

Equipment

For this investigation you may use either
(i) a lux lightmeter (expensive) or a light integrator (simply constructed and relatively inexpensive)
(ii) a black polythene bag
(iii) a note pad and pencil
(iv) Ammonia in a fume cupboard

Procedure

(1) If using the lightmeter, it is important to measure the light intensity under similar cloud conditions and with only a few minutes between each reading.
(2) Take a reading for each location selected and record this. Usually ten locations are chosen.
(3) With the light integrators, this process is simplified. Cloud variations are not as relevant because the integrator is in position for 24 hours.
(4) Place the integrators in selected positions for 24 hours.
(5) Return and collect the integrators, place them in the black bag to prevent further exposure. This would give a false reading.
(6) Develop the Diazo paper with ammonia vapour and count the number of sheets exposed.
(7) Locations are chosen by you, to meet your requirements. Here are a few suggestions:
    (a) inside/outside wood
    (b) under ferns
    (c) on mossy rocks
    (d) under different tree species.
    In all cases, note the flora near the location.
(8) Determine the percentage (%) light penetration using the following formula:

$$\frac{\text{Number of Diazo sheets exposed}}{\text{Number of Diazo sheets originally}} \times 100 = \%\ \text{exposure}$$

e.g. $5/15 \times 100 = 30\%$ exposure.

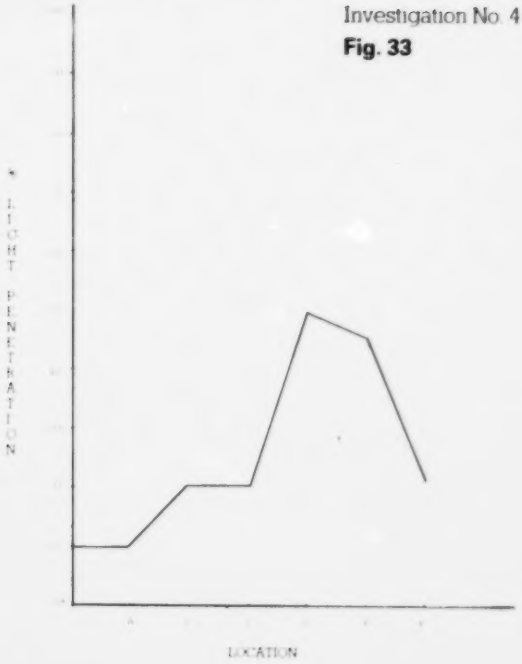
Penetration at this location is 30%.

Results

Graph your results for the various locations, e.g.

Investigation No. 4

Fig. 33



Points for Discussion

Plant distribution and their relationship to light intensity

The physiological effect of light intensity - consider compensation and dew point in relation to this factor

INVESTIGATION NO. 5 * ASSOCIATIONS OF ANIMALS WITH TREES

Introduction

All animals depend on plants as a source of food or for a place to live. The larger plants, such as trees, act as host to a variety of animals. Animals use both living and dead plant material for these purposes. In this investigation the diversity of animals present on trees will be examined and counted.

Equipment

You will need:

(i) a beating tray (a white sheet, or a piece of white plastic)

(ii) some sticks

(iii) collecting bottles

(iv) pooters

(v) selected guides (See Bibliography).

Procedure

(1) A number of people will be needed to perform this investigation.

(2) The beating tray is held open underneath the tree, usually by two people.

(3) Others from the group beat the branches above the tray with the sticks.

(4) Insects and other animals that fall onto the tray can be easily seen against the white background.

(5) Quickly collect them in bottles with a pooter.

(6) Identify these animals using the guides, recording the numbers of each.

(7) When all the results have been recorded, release the animals back into the wood.

This may be performed on a number of tree species for comparative results. Graph the results in a number of ways, e.g., chart, histograms, bar charts, etc. From the results, produce a food chain/web and write the method of adaptation of each animal to their niche. (A niche is the role of a species in a habitat - it includes diet, space, shelter and its method of acquiring food.)

Points for Discussion

State your conclusion under the following headings:

Adaptation and niche

Position in food chain

Competition

INVESTIGATION NO. 6 * FALLEN LOGS

Introduction

Decomposition of wood is very important in woodland ecosystems as it regulates the recycling of mineral nutrients and contributes to the development of soil. Even though the nutrient level of the wood is low, the sheer volume being decomposed in the woodland forms a very large section of the total minerals present in the ecosystem.

In a fully mature tree, 40 - 60% of the dry mass is cellulose. The degradation of this cellulose is an indispensible process for the woodland and the maintenance of the carbon balance in the ecosystem.

Wood degrading fungi have a higher moisture requirement in comparison to other fungal saprophytes. The optimum moisture content of the wood for fungal growth lies at approximately 40%, but this varies with the fungus and the wood.

The incorporation of decaying wood into the soil is greatly facilitated by animals. As various fungi species exploit the wood it softens and becomes more friable and as such becomes more attractive to animals, not only as a food source but as somewhere to live. They also eat the fungi.

The purpose of this investigation is to determine which flora and fauna aid in the decomposition of the wood and to determine any relationships which may exist between the wood, flora and fauna.

Equipment

For this investigation you will need:
(i) collecting bags and labels
(ii) white trays
(iii) a saw
(iv) callipers or ruler
(v) weighing scale
(vi) graduated cylinder
(vii) muslin
(viii) crucible
(ix) oven at 100° - 150°C
(x) collecting bottles with alcohol (70%)
(xi) Tullgren funnel apparatus
(xii) guides (See Bibliography)
(xiii) binocular microscope

(3) Return to the laboratory to perform the following tests.

The density of the timber should decrease as decomposition proceeds.

The density of each timber sample can be determined in the following way:-

(a) Cut a section measuring about 25mm X 25mm X 25mm from each sample and peel off any bark present.

(b) Weigh the section, record the weight.

(c) Calculate the volume of it with the graduated cylinder, i.e., place a known quantity of water in the cylinder, drop in the section - the amount of water displacement equals the volume of the section. (NOTE: Make sure that the timber is not touching the sides of the cylinder.)

(d) If the timber is badly decomposed, place some muslin (or a similar material) over the mouth of the cylinder when draining the water so that all the timber is collected.

(e) Place each sample in a crucible and dry in an oven at 100° - 105°C for 48 hours.

(f) After this period, calculate the density with the following formula:

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}}$$

(4) Describe the remainder of each sample in terms of appearance, hardness and smell and examine it for organisms. This can be performed in the following manner:-

(a) Check the bark for any growths, i.e., mosses, fungi, and/or any fauna - remove the flora, fauna and retain them for later identification.

(b) The sample can then be completely disintegrated by hand (or any other means), collect the micro-flora and fauna for identification it is best to use a Tullgren funnel - these animals are preserved in alcohol.

(c) The micro-flora and fauna are identified with the aid of a binocular microscope (d) and some selected guides.

Results

Below are some examples of the way that the results can be graphed.

Fig. 34 Investigation No. 6

Table - Number of fauna (decomposer organisms) present in ten samples of **Betula** and seven **Quercus** samples randomly collected in Cappawhite Wood.

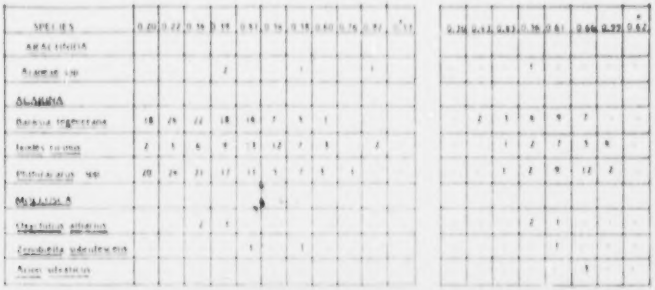


Fig. 34(a) Table: The flora present on the eleven **Betula** and eight **Quercus** samples randomly collected in Cappanalea Wood

DENSITY

SPECIES	0.20	0.22	0.39	0.39	0.91	0.56	0.59	0.60	0.76	0.92	0.99	0.36	0.83	0.85	0.96	0.61	0.66	0.99	0.62
MOSS																			
Dicranum scoparium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	∂	∂	-	-
Eurynchium praelongum	-	∂	∂∂	∂∂	∂∂	∂	-	∂	-	-	-	-	-	-	∂	∂	∂∂	∂∂	-
Hypnum cupressiforme	∂	∂	∂	∂∂	∂∂	∂	∂	-	-	-	-	-	-	-	-	∂	∂∂	∂	-
Lepidozia reptans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	∂	∂∂	∂	∂	-
Pohlia nutans	-	-	-	-	-	-	-	-	-	-	-	∂	-	∂	-	∂	∂	∂	-
Mnium hornum	-	∂	∂	∂∂	∂	∂	-	-	-	-	-	-	-	-	-	∂	∂	∂	-
Rhytidiadelphus loreus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	∂	∂	∂	-
Thuidium tamariscinum	∂	∂	∂	∂∂	∂∂	∂∂	∂∂	∂	∂	∂	∂	-	-	-	∂	∂	∂	-	∂
FERNS																			
Hymenophyllum		∂	∂	∂∂	∂∂	∂	∂	-	-	-	-	-	-	-	∂∂	∂	∂	-	-

∂ Traces of flora present ∂ Present ∂∂ Abundant

Points for Discussion

Discuss your results under the following headings:

The relationship of density and the stage of putrefaction (decomposition)

During this whole process, state the organisms that come into play at each stage, from the beginning right through until the timber is powder.

Relationships between flora, fauna and timber

Relationships between flora, fauna and different tree species

INVESTIGATION NO. 7 * GALLS ON TREES

Introduction

Many kinds of insects lay their eggs inside various parts of a plant. Often the affected part of the plant becomes badly damaged and it finally dies.

Some plants have developed a method of defence against this kind of attack. After the egg has been laid, the tissue begins to grow rapidly in the region of the egg. This forms a swelling called a **gall.**

The egg hatches inside the gall and the larva feeds and grows there, never leaving it. When it is fully grown, it changes into a pupa. After a while the skin of the pupa splits open and the fully-formed adult insect (also called an **imago**) emerges and burrows its way out of the gall. It flies away to mate, the female lays the eggs on a plant and the cycle repeats itself.

The plant has provided a home and nourishment for the larva and pupa but keeps it in one place where it cannot damage other areas of the plant. In this investigation you will examine the life cycle of an insect which initiates the production of galls in plants.

Equipment

To hatch the insect you will need:

(i) small jars (jam jars etc.) or plastic containers (yoghurt containers)
(ii) transparent plastic bags
(iii) rubber bands
(iv) thin garden canes
(v) cotton wool
(vi) paper tissues
(vii) potting compost
(viii) large ice cream cartons
(ix) a small jar of water
(x) a secateurs

In the second method for hatching, all you need are some:-

(xi) nylon tights and
(xii) rubber bands

Procedure

(1) Oak is a good tree on which to find galls. Choose a single tree in a hedgerow, rather than one in a woodland, as single trees tend to have more galls on them. (A tree at the edge of a woodland may also be used.)
(2) Search for galls in April or May.
(3) When a gall is found, decide whether it is still growing (usually in spring) or if it has fully grown.
(4) If it has grown fully, cut off the twig and wrap its cut end in tissue paper soaked in water.
(5) Seal it in a plastic bag and take it back to the laboratory.
(6) Place the plant in a cage, similar to that shown in the diagram. (See Fig. 35) Record the date.
(7) Make sure there are no cracks in the carton or the bag. These insects, even as adults, are very small - a few mm long and one or two mm wide.

(8) Moisture may collect in the bag. Wipe it off and turn the bag inside out, replacing it on the canes. When wiping the bag, look carefully for adult insects.
This should be done every few days - it only takes a few minutes!
(9) Sometimes the water in the jar may need to be topped up. Remember to keep the compost moist.
(10) Watch the galls carefully. Sooner or later, an adult insect may be seen crawling around the inside of the cage. Remove these and examine under a microscope.
Note the type of gall (describe shape, colour, etc.), the number of adults to emerge, the date of emergence.
Sometimes, larvae of other insects inhabit the galls and emerge as adults. These are called **inquilines.**
Describe the type of adult gall found;
Describe the number and types of inquilines.
(11) Check the number of galls and gall insects. Galls usually only contain one insect. Do the numbers of galls and emerged gall insects correspond? If not, could you give a reason. Could parasitism be involved?
(12) If you notice several exit holes but can't find any insects, it is possible that they have crawled down to the compost. Some gall insects do this to pupate. Wait a while longer for the adults to emerge out of the soil.
(13) Release the adults so that they can continue to live.

Alternatively

(14) If the tree is near you and if the galls are not fully grown, place a piece of nylon tights over the gall. Tie it on with a rubber band.
(15) Check the gall regularly until the adult emerges.
(16) Examine the insect as in the previous method.

Points for Discussion

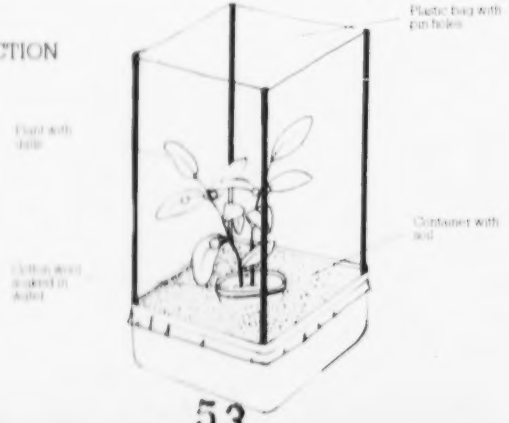
The impact of these insects on a plant.

Discuss their life cycle.

Relate this to other plants on which galls are found.

Fig. 35

CAGE FOR GALL COLLECTION



INVESTIGATION NO. 8 * ASSOCIATION OF PLANTS AND FUNGI

Introduction

Fungi **(Saprophytes)** are very important in any woodland ecosystem as they cause the degradation of dead or dying organic material. This recycling allows a lot of valuable nutrients to be released into the soil, enriching it and increasing their availability to other plants. In this investigation you will determine the relationships which exist between fungi, certain plants and various habitats.

Equipment

You will need:

(i) Fungi guides (See Bibliography)

(ii) collecting bags and labels.

Procedure

(1) It is best to identify the fungi on site as their collection in plastic bags can often lead to their decomposition in a few hours. While some fungi only appear during the autumn months, certain ones which live in association with trees can be seen all year round.

(2) Look for the fungi found in the following areas and identify them.

(a) deciduous woods.

(b) stumps.

(c) Polypores on Birch **(B. pubescens)**

(d) Agarics in the wood. (e.g. near Caragh Lake).

(e) Blue fungus on twigs and fallen logs. (See fungi section, Page 26, if unsure of fungal structure.)

List the fungi present and note where found.

Points for Discussion

The position of fungi - the similarity of conditions for growth.

The abundance of fungi in the different areas.

Adaptations of fungi to different growth patterns, e.g. on trees in comparison to the ground.

The role of fungi in a habitat.

Relationships between plants and fungi, and between animals and fungi.

INVESTIGATION NO. 9 * GROUND LAYER FAUNA

Introduction

Soil fauna consists of all the animal life from the single-celled to the multi-cellular organisms. The fauna is present in two main regions - the leaf litter (which consists of debris, dead leaves, decaying plant and animal remains) and the soil itself.
The type and amount of organisms found in the two layers differ due to the type of substratum in which they are found.
In this investigation, you will collect samples of material from each layer and extract the animals present in each.

Equipment

To collect the samples, you will need:-

(i) trowel
(ii) collecting bags and labels

To extract the fauna, you will need:-
(i) Tullgren Funnel apparatus
(ii) collecting bottles with alcohol
(iii) binocular microscope

Procedure

(1) Mark out a 5m X 5m quadrat area.
(2) Collect an equal number of samples from each layer inside the quadrat, e.g., ten litter and ten soil samples (depth 10cms).
(3) Label each correctly.
(4) Return them to the laboratory.
(5) Place the same amount from each sample onto the mesh platform of the Tullgren Funnel and switch on the light.
(6) Leave in that position for 24-48 hours.
(7) Store any specimens extracted in a collecting bottle for later identification using selected guides. (See Bibliography). The simple key in this book may also be used.

Results

To analyse the results, it is easier if the mean number of the fauna is calculated. Then graph your results - use histograms, bar charts, etc. Compare the numbers of each type of fauna found in the two areas.

Points for Discussion

Numbers of animals in each area.

Distribution of animals.

Adaptation to their way of life.

The role (niche) of the animals in the leaf litter.

INVESTIGATION NO. 10 * MEASUREMENT OF ENVIRONMENTAL FACTORS

Introduction

Climate plays a very important role in any ecosystem. Large climatic fluctuations can be detrimental to the plant and animal life within the ecosystem.

Each area has its own local fluctuations but these are usually minimal and the flora and fauna of the area can tolerate these due to their adaptation. The environmental/climatic factors include humidity, rainfall, temperature, wind and light. Over a short period temperature, humidity, light and wind can be measured.

However, a longer period of time gives a more accurate reading. Therefore, a weather station can be set up.

(The method for measuring light has already been outlined in a previous investigation.)

Any area can be used to measure these factors.

In this investigation you will measure:

(a) temperature
(b) humidity
(c) rainfall

Equipment

If you require measurements for just one day, the following equipment is needed:

(i) thermometer - temperature

(ii) swirling hygrometer - humidity

(iii) lightmeter - light

(iv) paper - wind

For daily readings over longer periods you will need -

(i) maximum-minimum (or ordinary) thermometer - temperature

(ii) wet/dry bulb thermometer - humidity

(iii) light integrator - light

(iv) rain guage

Procedure

(1) Temperature measurement - Simply measure the air temperature using the thermometer.

(2) Humidity measurement - To use the swirling hygrometer, you must turn it a number of times.
The level at which you swirl the hygrometer depends on your requirements. A number of heights may be taken so that comparisons of humidity at different heights may be made.

(3) Light measurement. Use a camera lightmeter.
(4) Wind measurement. To find the wind speed, simply mark a distance. Release a piece of paper. Record the time it takes to cover the distance.

$$\text{Wind Speed} = \frac{\text{Distance(m/s)}}{\text{Time(sec.)}}$$

For daily measurement it is best to set up a permanent location. At this location there should be a:

thermometer - to measure temperature
wet/dry bulb thermometer - to measure humidity
rainguage - to collect the rainfall.

The rainguage can be cylindrical shaped (a bottle) with a funnel on top. These instruments should be regularly (daily or twice weekly) checked to get an accurate meteorological (weather) record.
Record all your results.
Draw some graphs to show each factor clearly. (See Fig. 36a, 36b, 36c)

Fig. 36(a)

Mean rainfall (top) and maximum, minimum temperatures taken twice weekly from June to October 1984 and weekly from October to December 1984 in Cappanalea Wood.

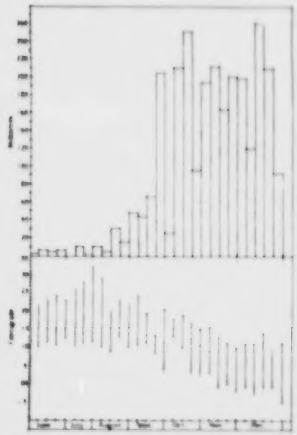


Fig. 36(b)

Fortnightly relative humidity values for three locations (see text) from June to December in Cappanalea Wood at arm's length overhead (top) and ground level (bottom).

Fig. 36(c)

Fortnightly humidity values for Cappanalea Wood measured twice weekly from June to October 1984 and weekly from October to December 1984.

Points for Discussion

Role of environmental factors in ecosystems.
Relationships between environmental factors and flora/fauna.
The existence of micro-climates in a habitat.
Measurement procedures for these micro-climates. (Try to think of some yourself.)

INVESTIGATION NO. 11

** ENERGY FLOW IN A WOODLAND ECOSYSTEM.

Introduction

An ecosystem is any unit which consists of living organisms and the non-living constituents of their environment. Various ecological concepts are examined at ecosystem level. These include succession and energy flow.

In this investigation, the energy flow in a woodland ecosystem will be examined. There are some related terms which you will need to know for this investigation. These are:-

(1) K cal - Kilocalories - a measurement of energy.

(2) energy flow - the flow of energy from one level to another.

(3) trophic levels - different levels in the ecosystem, each with its own category of organisms, ie: producers, consumers, etc.

Equipment

To perform this investigation, you use the results of some other investigations. The equipment you will need is as follows:

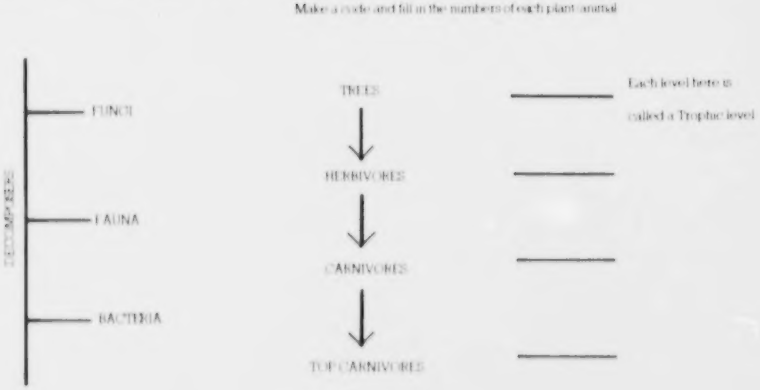
(i) some sticks
(ii) a measuring tape
(iii) builders' twine
(iv) plastic bags and bottles
(v) trowel
(vi) beating tray
(vii) quadrat (10cm X 10cm) and (0.5m X 0.5m)
(viii) record sheets
(ix) Tullgren funnel
(x) identification guides (See Bibliography)

Procedure

(1) Make a quadrat measuring 2m X 2m with the sticks and twine.
(2) Count the number of trees present. Using the random sampling method, estimate the ground cover for vegetation in the area with the 0.5m X 0.5m quadrat. Estimate the number of plants on the trees (epiphytes) using the 10cm X 10cm quadrat.
(3) Using the smaller quadrat, sample the ground layer for animals.
(4) Estimate the number of animals in the trees by using the beating tray. Place the white sheet underneath the trees and beat the branches with the sticks. Perform this on a number of trees.
(5) Identify all the animals present from the trees and ground layer. Divide them into primary consumers (herbivores), secondary consumers (carnivores) and decomposers.
(6) Record all your results.
(7) Draw a diagram showing the flow of energy from the trees to the decomposers. Include in this diagram the numbers of plants/animals in each category.
(8) Other biological processes which need energy have to be accounted for.

Results

Your diagram should look like this: **Fig. 39** RESULTS

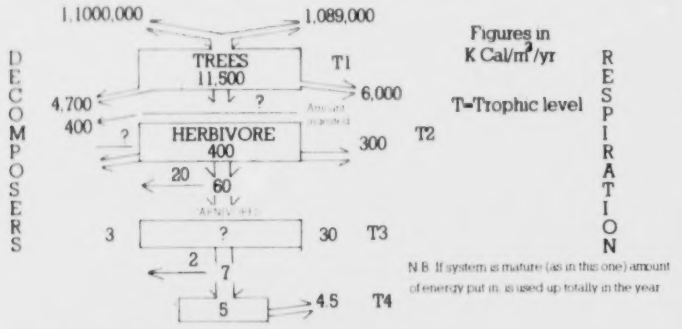


Include all your figures for each category.

Points for Discussion

In a mature ecosystem, the total input for a year is used. Therefore no energy is wasted. Between the different trophic levels, energy isn't wasted either, it is consumed by another trophic level, by decomposers, or is used up in respiration.
Keeping this in mind, fill in the blank spaces in the following energy flow diagram.
Remember all the figures must add up and also remember to add all the figures coming from one point first, e.g., T1 4,700 + 6,000 = 10,700 − 11,500 + 800.

Fig. 40 SUNLIGHT ENERGY Energy flow in woodland ecosystem.



Discuss the efficiency of energy flow in an ecosystem.
Using plants/animals from the different levels draw a food chain/web.
Discuss energy flow in relation to this food chain/web.

INVESTIGATION NO. 12 ** PRODUCTIVITY IN PLANTS

Introduction

Any flowering plant may be used in this investigation. However, for the purposes of describing the investigation, the Bluebell **(Endymion non-scriptus)** is the specimen selected. The investigation is directed at answering the basic question - why are bluebells more commonly found in shaded environments than in open ones?
Some answers to this question may be found by simply measuring the light intensity of the area and the subsequent variation in performance of the bluebell plants recorded.
In this investigation, you will measure the light intensity of an area and calculate the biomass of the bluebells present.
(Remember, any type of plant can be used.)

Equipment

You will need:

(i) a lightmeter or an integrated lightmeter
(ii) a notepad and pencil
(iii) some 0.25 m quadrats
(iv) clippers, collecting bags and labels
(v) oven at 95°C
(vi) weighing scales

Procedure

(1) Select a number of bluebell populations in what appear to be two contrasting shade conditions (e.g., inside and outside the woodland).
(2) Measure the light intensity reaching these areas. (It is important, to ensure accuracy, that all population measurements are made under the same weather conditions. Therefore, it may be best to use an integrated lightmeter.)
(3) Performance in the populations may be obtained by considering two possibilities:
(a) the average number of capsules and
(b) the number of seeds per capsule (both of which are best measured in July.)
(4) The biomass of the plants can also be used as a measure of its productivity. This is performed as follows:
(a) Place down a 0.25m quadrat.
(b) Clip all around it, leaving behind branches enclosed by the quadrat but rooted outside. Now clip and retain all the bluebell material within the quadrat.
(c) Oven dry at 95°C (a domestic oven is adequate, lay the material out on an oven tray). Express as dry weight per square metre.
(d) Dig the area enclosed by the quadrat, wash the roots, dry and weigh using the method above.
(e) Add to give total biomass.

Points for Discussion

What is the answer to the introductory question?
Area with the highest productivity.
Other factors affecting productivity.
Discuss your answer with regard to selection/adaptation/natural selection.

INVESTIGATION NO. 13 ** THE DISTRIBUTION OF LICHENS ON TREES IN AN AREA.

Introduction

Lichens grow profusely in this country. There are 1,400 different types recorded here, making Ireland one of the richest sources of lichens among the countries of Europe.

A lichen is a plant consisting of two parts, an alga and a fungus. The alga is the photosynthetic part of the plant while the fungus contributes various substances (sugars, enzymes, etc.) to the plant.

In this investigation, you will examine the distribution of lichens in an area, measure various environmental factors and determine their influence on lichen growth.

It is the association of lichens and trees that will be examined. A group of lichens living on trees is termed a **corticolous community.**

Equipment

The following equipment is needed to sample and identify the lichens:
(i) a quadrat (10cm X 10cm)
(ii) pins (those used for pinning the specimen to the board in dissections)
(iii) compass
(iv) record sheets **(See pages 121, 122)**
(v) identification guides (See Bibliography).
To measure the environmental factors use the appropriate equipment as follows:
(vi) rainfall - a water container
(vii) light - some type of lightmeter.

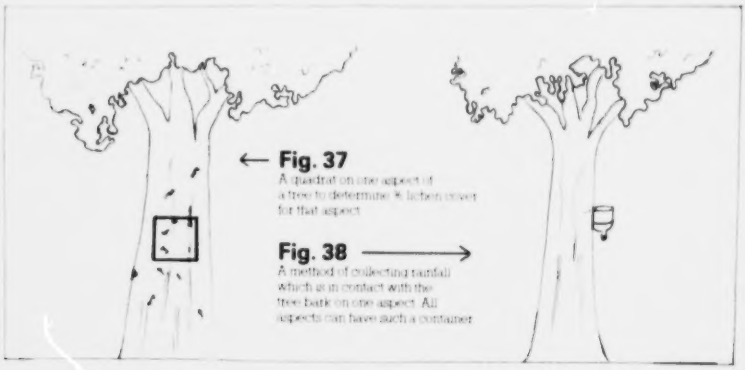
In a previous investigation, all epiphytes for an area were recorded. This list can help you, especially if you are investigating the lichen distribution in the same area. It should also aid in the identification of lichens.

Procedure

(1) Select a number of trees with good lichen cover. These can be used as end points for each line transect taken. (Different tree species may be used, but be sure to identify them properly and record their precise location.) Measure the length of the transects.
(2) Trees along or close to the transects should be surveyed for lichen cover, rainfall run-off and light intensity at the bark.
(3) The extent of lichen cover on the trees can be obtained using the following method:

(a) divide each tree into the four aspects, north, south, east and west, with the compass.
At breast height, mark each aspect with a pin.
(b) a quadrat (measuring 10cm X 10cm) is placed at each pin and the lichens present are identified and given a cover value.
(c) records may be kept on sheets similar to that shown here.

(4) Rainfall run-off may be recorded for each aspect if the tree's girth is large enough to hold four water containers. If not, two aspects (opposite, usually north vs south) may be used.
The water containers (a plastic litre drinks bottle halved will suffice) are attached to the tree by a carpet tack or with some twine and checked at regular intervals.
(See Fig. 38)



← **Fig. 37**
A quadrat on one aspect of a tree to determine % lichen cover for that aspect.

Fig. 38 →
A method of collecting rainfall which is in contact with the tree bark on one aspect. All aspects can have such a container.

(5) Light readings may be recorded for each aspect with a lightmeter of some type (e.g., Megatron Luxmeter Type DA 10 Mark 11).
A light integrator may be used but be careful attaching it to the tree. This factor should be recorded at least twice.

NOTE: This investigation is long term and should only be attempted if the area is to be visited regularly over a period of time.

The results of this project can be charted in different graphic forms.
Some of the graphs should include -
mean number of lichens per tree species
mean number of lichens on eash aspect per tree species
lichen species present/absent on/from tree species
lichen species present on each aspect of tree species
rainfall in contact with aspects over a period of time
lightmeter reading for the aspects of the different tree species.

Points for Discussion

It has been concluded by scientists that 60% of the variation in lichen communities could be ascribed to substrate factors and 40% to environmental factors. Did you find this to be the case?

Substrate factors include bark texture, bark pH and the water holding capacity of the bark.

Below are some trees with different properties.

Bark texture	Smooth	Rough
	Holly **(I. aquifolium)**	Oak **(Q. petraea)**
	Rowan **(S. aucuparia)**	
	Birch **(B. pubescens)**	

The birch has a peeling bark but it is smooth.

Bark pH range	Acid	Alkaline
	Oak	
	Willow	
	Birch	
	Holly	
	Rowan	

Water holding capacity - this is the ability of the bark to "give up" water.

Soft barked trees have a high water capacity and give water more slowly.

Bark	Soft	Hard
	Willow	Holly
		Rowan

Lichens spread vegetatively and by spores.

What influence, if any, would each of the characteristics above have on the establishment of the spores?

Leaking of nutrients from the bark can occur. This is caused by the flow of rain down the bark. What effect would this have on the growth of the lichens?

What influence, if any, does aspect have on the presence/absence of a lichen? Can aspect and light intensity or rainfall be connected to the occurance of a lichen?

OTHER WOODLAND INVESTIGATIONS

- A comparison of plantation and natural woodlands. This should include the:
  differences in stratification;
  differences in ground layer flora;
  density of trees in a 5m X 5m area;
  differences in fauna on trees and in litter.
  There are many other areas which may be included.

- Examine the ecotone (gradual change from one habitat to another) around the woodland.

- Adopt one tree and describe every feature of it. Record all its characteristics and try to visit it throughout the year so that the changes can be recorded.

- Collect seeds in the autumn. Describe their characteristics, i.e.,colour, shape, size, etc. Sow them and watch the germination process.

- Compare the canopy development in birch growing in woodland and in the open.

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HEATHLAND AND BOGLAND HABITATS

Often, it is difficult to distinguish between heathland and bogs on the basis of vegetation cover alone since both habitats share many plant species. A blanket bog is an area where peat has accumulated and the vegetation is rooted in this medium. A heathland, on the other hand, is a habitat in which the vegetation is rooted in the mineral soil.
On high sloping ground, which has relatively good drainage, bog development cannot take place.

In such areas, heathland or moorland develops. However, acidic soil conditions are present and the characteristic calcifuge vegetation of this heathland community exists. This includes the purple moorgrass **(Molinia caerulea)** which has bluish tinges on the leaves and grows in large tussocks; rushes and sedges in wetter areas and mat grass **(Nardus stricta).** In the drier areas, heathers such as bell heather **(Erica cinerea),** ling heather **(Calluna vulgaris),** and furze **(Ulex** species) are found. Two types of **Ulex** are seen, the dwarf or autumn furze **(Ulex galli)** which is seldom more than half a metre in height and the common furze **(Ulex europaeus)** which can grow up to three metres in height. The dwarf furze flowers in autumn and occurs only on high ground. The two species are rarely out of flower, giving rise to the saying - "Kissing is out of season when the furze is out of bloom".

The high, wetter moorland contains plant species which are of poor nutritional value to the grazing animals, for example, mat grass and purple moor grass.

Grasses of a more nutritional value are found on the drier moorland in lower altitudes. These include creeping bent **(Agrostis stolonifera),** velvet bent **(Agrostis canina)** and the red fescue **(Festuca rubra).** The drier type of habitat is quickly invaded by bracken **(Pteridium aquilinium)** which reduces the grazing value of the lands.

Bracken contains at least one compound which is carcinogenic (cancer forming) to grazing animals. This plant is also one of the very few plants which does not support an array of specific parasitic insects. The only one species that does effect it, is a fly larva which causes curling of the fronds of the plant. Flowering plants present here include the spotted moorland orchid **(Dactylorhiza majalis)** with its dense purple flower blooming from May to July. It is also called the western marsh orchid.

The area that now exists as moorland was probably more wooded in historical times. The downfall of the forests resulted from a wetter climate and the agricultural exploitation of the area. The grazing of domestic animals initiated and maintained the open moorland. This exploitation began about 3,000 years ago.

Like other rural areas in similar conditions, population in the region would have been larger than at present. However, the famine in 1847 caused a dramatic decline in the population. The fields that were once farmed are now being invaded by bracken, furze and holly, reverting back to a more natural habitat.

Bogs

The bogs around the south western area represent one of the three types found in Ireland - they are known as western blanket bog. They derive their name from the fact that they blanket the whole terrain with a layer of peat. This type is found mainly in areas of high rainfall and poor drainage. The flat and moderately sloping areas allow the development of this bog. Climate and vegetation also play an important role.

The peat itself is composed of the dead remains of vegetation which have accumulated over thousands of years. One very important plant group in the development and formation of peat is the **Sphagnum** mosses. These are also called the bog mosses and can be found also in woods and in pools.

Sphagnum mosses have many different colours from bright green to yellow or red tinged species. They are normally found growing in large tussocks or clumps. It is this growth pattern which aids in the "growth", or development of a bog.

All bog mosses, whether living or dead, have a unique ability to retain water like a sponge. Walk on **Sphagnum** and watch all the water that surrounds your foot. This is the main reason why, even in the rare dry summers, a bog is constantly wet.
Because of this high water saturation, oxygen is usually in short supply which in turn inhibits decomposition by microrganisms. The mosses also tend to acidify the water and this inhibits decomposition thus allowing the accumulation of peat.

This moss was used during World War 1 when cotton wool was unavailable to field hospitals. When applied to a wound, it soaked up the blood, while the acid it produced acted as a disinfectant.

The depth of peat varies between 0.2m and 2m and, where sufficient depth is present, turf cuttings are made. Towards the top layers, the dead remains of other bog plants such as heathers, grasses and sedges may be recognised. At the base or edges of cut away bogs, bog deal may be found this is the preserved remains of oak and scots pine which grew in the area 4,000 to 5,000 years ago.

Apart from preserving the timber present in the area, the exceptionally slow rate of accumulation in the bog provides a record of the past vegetation in and near the bog. This vegetational record is largely in the form of pollen grains which are blown onto and incorporated into the growing bog. Each plant species produces distinctive pollen - the outside of the pollen grain is remarkably tough and resistant to decay and possesses an elaborately sculptured wall. Through this characteristic, pollen grains which are present in the bog may be identified. By taking samples at different depths, identifying and counting the pollen grains present, a vegetational history of the area can be constructed. (A simplified technique for pollen analysis is available in the book by Gimingham - An Introduction to Heathland Ecology, 1975)

Most plants found in the bog are strict calcifuges, i.e., they don't grow in alkaline conditions. The characteristic plants here include the heathers - bell heather **(Erica cinerea),** and ling heather **(Calluna vulgaris).** Other plants present are some sedges, including the flea sedge **(Carex pulicaris),** deer grass **(Scirpus caespitosus),** bog cotton **(Eriophorum angustifolium)** and the bog rush **(Schoenus nigricans).** This last plant is a distinctive plant of western blanket bogs. Another plant, the bog asphodel **(Narthecium ossifragum),** is easily identified by its small, distinctive, sword-shaped, iris-like leaves while spikes of starlike 6-petalled orange-yellow flowers appear in July/August, giving rise to deep orange fruits.

Lichens **(Cladonia)** are also found here. They produce red fruiting bodies in sharp contrast to their green "stalks" and, strangely, some are called deer moss.

One problem encountered by plants growing in the bog habitat is the scarcity of essential nutrients, especially nitrogen and phosphorous. Few minerals are available to plants because the medium lacks these substances - this is a result of the formation process.

Plants have, in various ways, adapted to this problem, e.g., one special group has a carnivorous lifestyle and, while they may not look as threatening as the venus fly-trap, to the insect they are just as deadly. Here in Ireland two such species exist.

Drosera or sundews are small plants with interlocking leaves (somewhat similar to the hands held with the palms open). The rosette of leaves is covered with sticky red hairs which curve inwards to trap the insects. These hairs also secrete digestive enzymes which digest the victim while the leaves absorb the nutrients.

Another group of plants, the butterworts, follows this diet also! However, the species present here, the greater flowered butterwort **(Pinguicula grandiflora)**, is more conspicuous. It is the largest of all the species and has been called by botanists 'The most beautiful member of the Irish flora'. Hooded, deep purple flowers crane forward on four to six inch stems from the end of May until June. The rosette of leaves, which are pale green-yellow in colour, produce the sticky substances which entrap the insects. Once trapped, the leaves curl up at the edges and devour the insects. The leaves are visible for most of the year. However, during winter a small bud-like structure appears at the site of the old leaves which have withered and this structure contains the new leaves of the plant. This plant is very common around Cappanalea and is one of the country's Lusitanian Flora with a rare distribution pattern. (See Lusitanian Flora and Fauna.) Even though these plants are carnivorous, they still photosynthesise as they possess chlorophyll. Their carnivorous nature supplements their 'diet'.

In the boggy areas, particularly near lakes, a low growing shrub of approximately one metre in height may be found. This shrub, bog **myrtle (Myrica gale)**, produces highly aromatic young buds and leaves. It was used instead of hops in medieval times by the Danes to flavour beer.

Areas that are marshy or 'boggy' exist both on the higher, more level areas and down near the lakes. These usually consist of various **Sphagnum** mosses including **S. compactum, S. palustre** and **S. rubellum** (which is red in colour). These mosses make the area look and feel like one big sponge. Towards the edge of these areas other mosses, such as **Polytrichum commune,** are present. This moss can grow to quite a height - 40cms - in large cushion-like clumps. Look for spore containers on the mosses!

Other plants present include the rushes, indicative of a wet soil, poor in nutrients and generally waterlogged. The species present include the sharp-flowered rush **(Juncus acutiflorus)**, the soft rush **(J. effusus)** and the jointed rush **(J. articulata)**.
Sedges and grasses present include the greater tussock sedge **(Carex paniculata)** and black bent **(Agrostis gigantea)**.

Flowering plants in marshy areas include tormentil **(Potentilla erecta)**, marsh foxtail **(Alopecurus geniculatus)**, lesser spearwort **(Ranunculus flammula)** and marsh pennywort **(Hydrocotyle vulgaris)**. Some of these plants become more abundant in slightly drier areas.

Animals In Heathlands and Bogs

The animals are captured using any of the techniques previously discussed. Invertebrates may also be extracted and identified using the methods described.

Among the larger animals on the heathland, you may see different types of birds, particularly pheasant **(Phasianus colchicus)**. Grouse **(Lagopus lagopus)** are also present. They may be difficult to see but watch out for their clues, grouse droppings. The droppings are usually the colour of the food eaten. They can be green, red or a mixture of colours. Rarely are grouse droppings regular in shape - more often they will look like a mess of jelly.

Hares and rabbits should also be seen. Look for evidence of foxes in the areas. Domestic animals, cattle and sheep, graze the area, sometimes a lost red deer **(Cervus elaphus)** may also be spotted.

In February/March frog spawn may be found in bog pools at numerous locations, both on the higher altitudes and near any of the small lakes.

INVESTIGATION NO. 14

* THE INFLUENCE OF ALTITUDE ON A SELECTED PLANT SPECIES

Introduction

Many factors influence plant growth and the distribution of a plant. These include soil (edaphic) factors, climate and altitude.
In this investigation the influence of altitude will be examined.

Equipment

You will need -

(i) a quadrat
(ii) a line transect
(iii) a map of the area (Ordnance Survey map)
(iv) a record sheet
(v) poles, protractor

Procedure

(1) Select an area of heathland and find it on the Ordnance Survey map.
(2) Record the altitude of your starting point and mark it with a pole.
(3) Choose your plant species, e.g. rushes.
(4) Lay down your line transect and place the quadrat at selected intervals.
(5) Give your plant a cover value and record this.
(6) Note all the results of your quadrats as you move up along the area.
(7) When the plant species doesn't appear any more in your quadrats, mark that point with a pole.
(8) Using the protractor, determine the slope of the area as outlined in the Techniques section.
(9) Estimate the altitude using the distance covered by the line transect and the angle. (Assume that you have a right angle in the triangle.)
Alternatively, you may be able to read the altitude from the map if a definite point is seen on the map.

Results

Chart the results in a trend graph so that the distribution of the plant species may be seen.
Does the distribution of the plant species become more or less abundant with increasing altitude?

Points for Discussion

The influence of altitude on plant distribution.
The effect of altitude on other factors such as soil, climate.
How all the factors influence distribution and growth.

INVESTIGATION NO. 15 * SUCCESSION IN HEATHLAND

Introduction

Heathland is set alight almost every year. The heathers are burned and only charred skeletons remain.
Farmers set this area on fire so that new grasses may grow; grass which is more palatable and nutritious to their grazing sheep and cattle.
In this investigation, you will examine the plants which colonise such burned areas first - these are called pioneers. A permanent quadrat will be left in place to enable a study of the plants which invade the area after the pioneers. Such an investigation will continue until the climax community (heathers) is visible (no matter how small).

Equipment

You will need:

(i) some builders' twine
(ii) some sticks
(iii) a measuring tape
(iv) some results sheets

Procedure

(1) Ask permission from the landowner to use a small section of land. Explain what you want to do.
(2) Construct a small quadrat (eg. 1m X 1m) using the twine, sticks and measuring tape, on land recently burned.
(3) Record the date and what is present in the quadrat.
(4) Return, at intervals, and record all the changes. Include in this record, the type and abundance of plants found. Record all dates of visits to the site.
(5) Take up the quadrat once the climax community has formed.

Results

Draw a diagram showing the process of succession from the burned soil to the climax community.
Draw graphs to show when plants appear, their abundance and gradual decline.

Points for Discussion

Discuss succession - how it occurs, etc.
How the process occurs naturally, without man.
Discuss succession in relation to other habitats.

INVESTIGATION NO. 16

* LINE AND PROFILE TRANSECT OF A SLOPING SITE

Introduction

To examine the type of vegetation in an area, a survey must be completed. A transect is one method of surveying an area. In this investigation, a sloping site in a heathland habitat is to be used. Interesting areas would include a transition from heathland to woodland or some similar conditions.
The area of transition between the heathland and woodland is termed an ecotone.
This is an indepth study encompassing the vegetation, soil and slope of the area. Soil samples will be collected and they will be tested for pH and percentage (%) Organic Carbon (O.C.). % O.C. is a measure of the humus content of the soil.

Equipment

To perform this investigation you will need the following:

(i) a line (marked at intervals of 1m if so wished)
(ii) some quadrats (0.5m X 0.5m)
(iii) two poles (your height at least)
(iv) collecting bags and labels
(v) one protractor, measuring tape and field (spirit) level
(vi) pencil and notebook (or prepared record sheets)

In the laboratory you need:-

(vii) a number of weighed crucibles
(viii) weighing scales
(ix) bunsen burner

Procedure

(1) Using the line and quadrat, sample the area by the line transect method.
(2) Estimate the species cover using the scale already quoted.
(3) Species should be identified in situation or collected if necessary. Remember to label **all** samples.
(4) **Slope Measurement**
At certain points measure the slope using the technique previously cited, with the two poles and protractor.
(a) Record the angle.
(b) Determine the height using the field level, measuring tape and poles.
(c) Record this variable.
(d) Later draw the profile of the slope including the angle and height of the slope.
(e) At the 1m intervals collect some soil samples. Perform the following tests on them back in the laboratory.
(5) **Determination of soil pH.**
(a) It is best here to use the pH meter.
(b) First, make a soil solution from each sample in the ratio of 2:1.
(c) Standardise the pH meter in a buffered solution.
(d) After the pH meter has been standardised, place the probe into the solution and leave it there for a few moments.

(e) Stir it around and allow it to settle.
Once the figure on the digital readout remains constant, note this figure. Repeat the method for all the samples.
Alternatively, if a meter is not available, place some Universal litmus indicator into some soil solution in a test tube.
Shake well.
Compare results on the chart with your results.

(6) **Determination of % Organic Carbon.**

(a) Using the remainder of the soil sample, perform the following test - Weigh a crucible and add a known quantity of dry soil.
(b) Record the weight.
(c) Place the crucible with its contents into a fume cupboard (or take the crucible to an isolated part of the room) and incinerate the soil until only ash remains.
(d) Weigh and record.
(e) Repeat the incineration for a few minutes. Reweigh - if the two weights correspond, calculate the % O.C. using the formula below. If they do not correspond, then continue the incineration until the two measurements are corresponding.
(f) Substitute the figures obtained into the formula:

$$\% \text{ O.C.} = D/WI \times 100$$

Where $D = WF - WI$

WI = Initial Mass

WF = Final Mass

And record the % O.C. for each sample.

(7) **Water content of soil.**

(a) This is determined by placing a known mass of soil into a crucible, the mass of which has previously been determined.
(b) Place the crucible in an oven at 105° – 110°C for 48 hours.
(c) Remove from the oven.
(d) Place the crucible in the dessicator to prevent moisture uptake while cooling.
(e) Again find the mass of the sample.
(f) % water content is calculated by using the formula:

$$\% \text{ water content} = D/WI \times 100$$

$D = WF - WI$

WI = Initial Mass

WF = Final Mass

Results

Draw a diagram of the site you have surveyed and include information on it concerning:
(a) dominant vegetation
(b) pH of soil
(c) % O.C.
(d) % water content.

Points for Discussion

The influence of soil (edaphic) factors on plant growth, i.e. abundance and type of plants present.
The effect of soil on plant growth, i.e., aspect.
The influence of slope on soil development.

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INVESTIGATION NO. 17 ** BOG DEAL IDENTIFICATION

Introduction

'Bog deal' or 'bog oak' is the preserved remains of trees which once existed in an area 4,000 - 5,000 years ago. Even though the name implies that the timber is deal or oak, this is not always the case. Pine **(Pinus** species) or any tree or piece of timber found in this preserved state in a bog/heathland belongs to this category. The test outlined below aids in the identification of this timber.
In this investigation, you will collect a number of bog deal samples and identify them.

Equipment

This project involves hazardous chemicals so **take care** when using them. They are:-

Phloroglucinol (1%) in water or ethanol (Phloroglucinol solution prepared by the addition of 5g of Phloroglucinol to 100cm^3 of 75% alcohol)

Hydrochloric acid (70%)

Other equipment needed includes:

collecting bags and labels

Light microscope and slides

Procedure

Collect a few samples of bog deal from various locations.

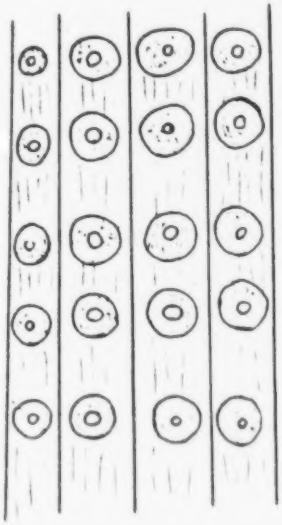
Label where found.

Return to the laboratory with them and identify them using the following techniques:-

(1) Clean the sample
(2) Cut a thin longtitudinal section from the sample with a blade.
(3) Place on a slide and stain the section with the Phloroglucinol solution for 2 minutes.
(4) Blot off
(5) Apply the HCL for 1 minute
(6) Wash off and blot dry
(7) Place on a clean slide
(8) Examine with the Light microscope under the X40 magnification.
(9) Sketch what you see
(10) The identification is based on the presence of bordered pits in the walls of the conducting vessels. These pits positively indicate that it is a coniferous tree such as Scots Pine **(Pinus sylvestris).** Hardwood trees such as Oak **(Q. peterea)** lack these. Ask your teacher to help you with the cutting of the section and identification of the pits.

Figure 41 shows what to look for when identifying bog deal.

Fig. 41
Longitudinal section of coniferous tree showing bordered pits on walls of conducting vessels.



Results

Record the numbers of hardwoods/coniferous trees in your samples.

What did you see?

Points for Discussion

The past vegetation of the area, i.e. type of trees.

Any factor influencing this.

OTHER SUGGESTED INVESTIGATIONS

** Examine the peat for pollen grains. This, when carefully performed, gives a vegetational history of the area. The pollen grains of past plants are preserved in the peat. Cumingham (See Bibliography) gives the method to follow.

** Microclimatology measurement - Microclimates are produced in microhabitats such as under heather, beside a bank of turf, etc. The measurement of these climates makes an interesting investigation. Use thermometers, shielded from direct sunlight with cooking foil, to record the temperatures of microclimates. For instance, measure the temperature at different heights in a stand of ling heather. Compare this with an uncovered area on a summer's day where it may reach up to 40°C.

** Litter measurement - put out small traps beneath the heather. Weigh the litter that falls into the traps.

** Insects visits to heather - During the spring/summer select a number of heather plants. Sit at the plant for a number of hours and count the number and type of insects that visits the plant for food. Compare your results for different times (seasons), various heathers, and when the plant was visited.

AQUATIC HABITATS

At an altitude of 400 feet above sea level, the aquatic habitats found are mainly freshwater. Due to the fact that bogs/heathlands are prevalent around the lakes, etc., water flowing into these lakes is usually low in nutrients. This creates a type of habitat termed dystrophic lake which is more fully described here.
Smaller ponds and rivers are also covered in this section.

Classification of Lakes.

Lakes are classified according to their nutrient status. Eutrophic lakes are rich in nutrients; they support large amounts of plankton and other plant and animal life. In Ireland, these types of lakes are found in lowland limestone situations which include the large midland lakes and Lough Leane, Killarney.

Oligotrophic lakes are low in nutrients and, consequently, support small numbers of plankton and relatively less plant and animal life. The lake itself is deep, poor and clear. A reasonable variety of species is present but the teeming numbers found in the richer lakes are not present. In Ireland, these lakes occur on sandstone and granite substrates. Caragh Lake is an excellent example.
As a poor lake becomes richer, its status and abundance of life changes. This enrichment can come from a variety of sources, both natural and artificial. This process of enrichment is termed eutrophication.

A third category of lake exists and these are termed dystrophic lakes. Such lakes have an accumulation of organic matter and have characteristically boggy brown coloured water. Those lakes are found in areas of high peat and in hollows between bogs.
Lakes at this altitude that may be poor in nutrients are best considered dystrophic, due to the high amount of water flowing in from bog sources.

Plantlife in Dystrophic Lakes.

The vegetation present in the lakes consists of three types:

(1) free-floating
(2) floating but attached to the lake bed
(3) emergent.

Free Floating plants consist mainly of the duckweeds, (**Lemna** species). These are tiny, only a few millimetres across, yet each plant consists of a complete flowering plant - however, it is extremely difficult to find them in flower.
Because they are free-floating, they can be found in every part of the lake, although they seem to prefer the areas where the water is very still. They send minute roots down into the water and become so common in an area that they can carpet the water surface.
One of the more conspicuous plants which are rooted in the lake bottom and have surface floating leaves is the white water lily **(Nymphaea alba).** The floating leaves are heart-shaped. From June until August, it possesses a large white flower about 15 centimetres in diameter. The plants are present in the sheltered western and eastern sides of the lake. During summer, these two sides of the lake become a mass of lily pads.
Other plants which are present all along the shoreline, and floating in the water, include the awlwort, **(Subularia aquatica)** and the water lobelia **(Lobelia dortmanna).** These two plants produce leaves similar in shape and size to another lakewater plant, shore weed **(Littorella uniflora).** The difference between the plants only becomes obvious at flowering - **Subularia** produces a short inflorescence of small white flowers while the

Lobelia brings forth a long graceful spike of purple flowers. The leaves of these plants float, while the flowers emerge from the lake. The submerged plant, shoreweed **(Littorella uniflora),** on the other hand, is closely related to the plantains. It is recognised by its tufts of narrow rush-like leaves, 5 to 10 centimetres tall. If the plants are left high and dry in summer, they will flower.

Emergent vegetation along the shore includes the wood club-rush **(Scirpus sylvaticus)** with its long inflorescence in June; devil's-bit scabious **(Succisa pratensis)** with its characteristic delicately coloured purple-red flower heads. The heads are on top of long stalks. Some of these plants have their roots submerged in water for most of the year.

Other plants growing in the bank but with some roots floating in the lake, include the royal fern **(Osmunda regalis),** various grasses and some trees, Birch, Willow and Holly. Wet areas surrounding the lake have plants such as yellow iris **(Iris pseudascorus)** (with its long slender leaves topped with a yellow flower in July), cowbane **(Cicuta virosa)** (producing its umbel which is poisonous to animals in July), and of course mosses, particularly **Sphagnum** species. In drier areas around the lake, mat grass **(Nardus stricta),** ling heather **(Calluna vulgaris),** creeping bent **(Agrostis stolonifera),** and the hard fern **(Blechnum spicant)** may be seen.

During winter, if the water turns to ice, watch what happens to the floating vegetation. The vegetation exhibits zonation in the lake itself.

FRESHWATER ANIMAL LIFE

Freshwater contains a multitude of life and the main groups present are:

(1) the invertebrates (without backbone)
(2) the vertebrates (with a backbone)

The invertebrates fall into two main categories:

(a) those that spend their entire life in the water, for example, the sponges and waterbeetles.
(b) those that spend only part of their life in the water, usually as larvae. This is particularly the case with insects. As adults they generally fly about in the vicinity of water.

The various animals found will be classified into locations such as surface, free swimming, bottom, etc.
Firstly, the surface dwellers:
These include the water measurers and skaters **(Hydrometra, Gerris** and **Velia** species). These insects are well adapted to their mode of life - they possess hydrophobic hairs which allow them to run along the water surface.
The water boatman **(Corixa** and **Notonecta** species) possess specially adapted 'feet' which are flattened like oars. This allows them to perform a rowing action. which gives them their name. Watch for the whirligig beetle **(Gyrinus)** which wheels about in large groups on the water surface. If disturbed they dive for safety. **Gyrinus** have a very special adaptation to life on the surface - their compound eyes are divided into an upper part for aerial sight and the lower part for peering down into the aquatic habitat.

Next, those animals that live between the water surface and base of the lake/river.
These include:
Insect larvae such as the mayfly larva **(Ephemeroptera)** which has three 'tails' (or tail processes). It has its gills positioned along the abdomen. Another larva present is the

caddis fly **(Trichoptera)** which lives in a case. This case is made of material from the habitat, e.g., a stony case would indicate that a stony bed is present.
Stonefly larvae **(Plecoptera)** may also be found. These are similar to mayfly larvae but have only two 'tails'.

Other animals present in this area include the smaller planktonic fauna. These microfauna look grotesque and weird under the microscope but are really harmless creatures - little creatures such as the water flea **(Daphnia)** and the **Cyclops.** The **Cyclops** is easily identified by its eyespot on the top and the eggsacs down by its sides. Many of the insect larvae feed on these planktonic animals.
Additional insect larvae include the mosquito larva **(Culex)** and pupa; the blackfly **(Simulium)** and the dragonfly larva **(Anisoptera).**
These animals may be found on stems of vegetation as well as free swimming or on the lake bed.
In rivers, the insects are adapted to the fast flowing water. They are flattened a lot more to produce less resistance to the flow of water and are usually found underneath the rocks and stones.

On the lake bottom, various beetle larvae may be found. These have long pincers/jaws which allow them to catch their prey. They are vicious larvae for their size, particularly to their prey. Many of these are carniverous and live on the smaller larvae present in the lake.
Many of the other animals found in this area are detrivores which catch the dead, rotting plant and animal material which sinks to the bottom of the lake. Large numbers of these indicate that eutrophication (or enrichment) has occurred. These animals include the freshwater louse **(Asellus)** and the freshwater shrimp **(Gammarus).** The shrimp swims along on its side (it is flattened ventrally) and is very distinctive because of this. The louse looks similar to the one found on land.

Snails can be found on vegetation near the water surface, below the water surface or on the lake bed.
(See Fig. 42 Page 120 for further examples and relevant guides.)

Vertebrates in lakes are usually fish - either salmon **(Salmo salar)** rainbow trout **(Salmo gairdnerri)** or brown trout **(Salmo trutta).** Additional fish include char **(Salvelinus alpinus),** pike **(Esox lucius)** and perch **(Perca fluviatilis).** The latter fish would only be found in areas where the freshwater lakes have become enriched.

Visitors to the lakes and ponds include the common frog **(Rana temporaria),** another vertebrate. This amphibian lays its eggs in aquatic habitats as the tadpole stage is totally dependant on water.

Adult insects are regular visitors to the lake, particularly in summer, to lay eggs. These include the mayflies, damselflies **(Zygoptera species)** and dragonflies **(Odonata species).**

INVESTIGATION NO. 18 * THE DETECTION OF MICRO ORGANISMS IN WATER SAMPLES

Introduction

Water is a very important medium in the mechanics of life in any ecosystem. Even a small drop of water contains life and in this investigation you will test for these micro organisms. This investigation aims to examine and count the colonies of micro organisms from water samples using non-selective agars. The investigation has an added interest for students since it may be incorporated into the appropriate sections (microbiology) of the Leaving Certificate programme in Biology.

Equipment

You will need

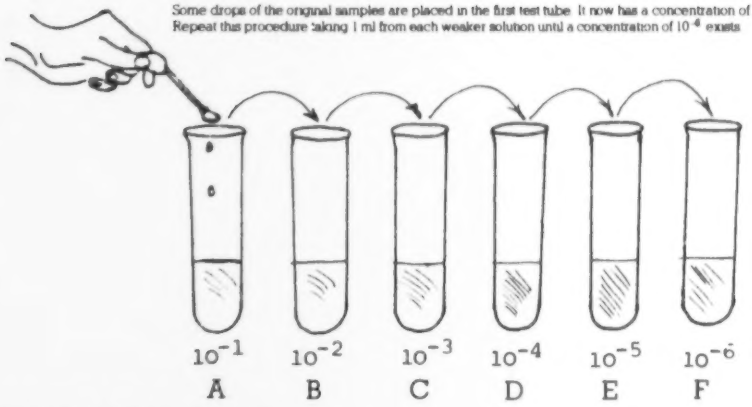
(i) sampling bottles and labels
(ii) sterilised pipettes and test tubes
(iii) inoculating loops
(iv) alcohol
(v) bunsen burner
(vi) petri-dishes with nutrient agar

Procedure

(1) Collect some water samples from various sources, e.g. the lakes, bog pools, dykes, streams, etc.
(2) Back in the laboratory, serially dilute the sample to 10^{-6}
(3) This is performed by taking $1cm^3$ of the sample and placing it in $9cm^3$ of distilled water (A). The dilution in this test tube is 10^{-1}
Remove $1cm^3$ from this test tube (A) and place it in test tube (B) (9ml of distilled water.) The dilution is now 10^{-2}
Remove $1cm^3$ from (B) and place in $9cm^3$ distilled water (C). Dilution is now 10^{-3}
Pipette $1cm^3$ from (C) and place in $9cm^3$ distilled water (D). Dilution is now 10^{-4}
Pipette $1cm^3$ from (D) and place in $9cm^3$ distilled water (E). Dilution is now 10^{-5}
Remove $1cm^3$ from (E) and place in $9cm^3$ distilled water (F). Dilution is now 10^{-6}

NOTE: It is important to use a new pipette for each transaction or contamination will occur.

Fig. 43 A SERIAL DILUTION



How to serially dilute water samples.

(4) Mix the sample thoroughly in all test tubes.
(5) Then, using a sterile inoculating loop, transfer a few water droplets from the original water sample to the agar and swish the water around the petri-dish.
(6) Close the petri-dish and label correctly.
(7) Dip the inoculating loop in the alcohol to sterilise it and flame dry the loop.
(8) Allow the loop to cool.
Repeat this process twice with each of the diluted samples, 10^{-1}, 10^{-4} and 10^{-6}
(9) Incubate at 48°C for 24 - 48 hours in an inverted positon, check for colonies of microorganisms after this period.

Results

Sketch the types of colonies present on the dishes.

Count the numbers of colonies on each plate.

Points for Discussion

The quality of water from various sources.

The numbers of various micro organisms from various sources.

The factors influencing the 'richness' of the sample.

INVESTIGATION NO. 19

** TO DETERMINE OXYGEN CONCENTRATION IN WATER SAMPLES

Introduction

The quantity of dissolved oxygen in standing water is of prime importance. This is due to the fact that the amount of oxygen which can be held in water is small compared to the amount present in the air. The rate of diffusion of oxygen in water is many times less than in air with the result that the level of oxygen is often much more critical in aquatic than in terrestrial habitats.

The quantities of oxygen present in a lake or pond ecosystem depend on three basic factors:

(a) the extent of contact between the water and the atmosphere;
(b) the circulation of water within the system; and
(c) the amount of oxygen produced and consumed within that system.

In this investigation, the oxygen concentration in a sample of freshwater will be determined.

Two methods will be discussed. The first is included as many schools possess most of the chemicals and equipment; the second is a newly developed method.

Equipment

To collect the sample you will need:

(i) a collecting bottle (125cm)
(ii) a thermometer

To determine the oxygen concentration you need:

(i) burettes
(ii) pipettes and beakers
(iii) Sodium thiosulphate 2.5m mol l^{-1}
(iv) Alkaline iodide solution
(v) Manganese (II) sulphate solution ($MnSO_4$)
(vi) phosphoric acid (concentrated)
(vii) starch indicator

NOTE: To prepare the reagents you must do the following:

(i) Dissolve 1.24g Sodium thiosulphate in distilled water add a pellet of NaOH and dilute to 1 litre. Store in a brown bottle.

(ii) Sulphate solution.

(iii) Dissolve 500g of Manganese in distilled water and make up to 1 litre.

(iv) Disperse 1g starch in 100cm^3 water, warm to 80-90°C. Stir well, allow to cool, add 0.1g salicylic acid.

Procedure

METHOD 1.

This procedure normally applies to bottles with a capacity of 125ml. The amounts of reagents and calculations need to be adjusted for other sizes.

(1) Take a water sample - fill the bottle to the top. Cork it tightly to prevent oxygen staying in the bottle.
Record the water temperature.
Return it to the laboratory.
(2) The water sample can be placed in a cool, dark place overnight if the remainder of the investigation cannot be performed.
(3) Add 1cm^3 of MnSO followed by 1cm^3 alkaline iodide to the sample.
(4) Replace stopper carefully, excluding air bubbles.
(5) Invert and rotate the bottle for 10 seconds. Allow to settle, remix and then allow to settle.
(6) Once this has been done, the remaining titration can be performed some hours later, provided the bottles are kept cool and in the dark.
(7) Add 2cm^3 of phosphoric acid.
(8) Replace the stopper and remix. Watch the precipitate dissolve.
(9) Measure into a conical flask either the whole sample or an aliquot (a sample of, say, 50cm^3) using the pipettes.
(10) Add 2cm^3 of starch indicator to the aliquot.
(11) Titrate this with sodium thiosulphate.
(12) Watch for a change in colour; when the purple colour disappears, stop the titration.

NOTE: When performing the titration, keep mixing the liquid in the conical flask to ensure accurate results.

Record all your results.

Then perform the calculations by using the following formula:

$$X = \frac{8.0\ C_{iii}\ V_{iii}}{V_t\,(V_f - 2.0)/V_f}$$

where

X = Oxygen concentration

C_{iii} = Concentration of Sodium thiosulphate, m mol l^{-1}

V_{iii} = Volume of Sodium thiosulphate, cm^3

V_t = Volume of aliquot titrated, cm^3

V_f = Volume of sample bottle with stopper in place, cm^3. (Easily measured by weighing empty and full bottle.)

Results

For example if your results were as follows:

C_{iii} = 2.5m mol l^{-1}
V_{iii} = 8.6 cm^3
V_t = 50cm^3
V_f = 174.8cm^3 then the calculation would be:

$$X = \frac{8.0 \times 2.5\text{m mol l}^{-1} \times 8.6\text{cm}^3}{50\text{cm}^3\,(174.8\text{cm}^3 - 2.0)/174.8\text{cm}^3}$$

(Substract 2cm³ when 2cm³ was added in step 3 of the Procedure)

$$= \frac{8.0 \times 2.5 \text{ m mol } l^{-1} \times 8.6 \text{cm}^3}{8640 \text{ cm}^3 / 174.8 \text{cm}^3}$$

$$= \frac{8.0 \times 2.5 \text{m mol } l^{-1} \times 8.6 \text{cm}^3}{49.4 \text{cm}^3}$$

$$= \frac{172 \text{m mol } l^{-1} \text{ cm}^3}{49.4 \text{cm}^3}$$

$$= 3.48 \text{ m mol } l^{-1}$$

Temperature = 11.4
Solubility from graph = 10.91
100% O_2 saturation = 10.91

$$\therefore \% \text{ } O_2 \text{ saturation} = \frac{0.48}{10.91} \times 100$$

= 31.9 O_2 concentration

Table Solubility of O_2 in water in equilibrium with air at 760 mm Hg pressure and 100% relative humidity (from EAWAG 1973) Units: mg l^{-1}

°C	0.0	1	2	3	4	5	6	7	8	9
0	14.60	14.56	14.52	14.48	14.44	14.40	14.36	14.33	14.29	14.25
1	14.21	14.17	14.13	14.09	14.05	14.02	13.98	13.94	13.90	13.98
2	13.83	13.79	13.75	13.72	13.68	13.64	13.61	13.57	13.54	13.50
3	13.46	13.43	13.39	13.36	13.32	13.29	13.25	13.22	13.18	13.15
4	13.11	13.08	13.04	13.01	12.98	12.94	12.91	12.88	12.84	12.81
5	12.78	12.74	12.71	12.68	12.64	12.61	12.58	12.55	12.52	12.48
6	12.45	12.42	12.39	12.36	12.33	12.29	12.26	12.23	12.20	12.17
7	12.14	12.11	12.08	12.05	12.02	11.99	11.96	11.93	11.90	11.87
8	11.84	11.81	11.78	11.76	11.73	11.70	11.67	11.64	11.61	11.58
9	11.56	11.53	11.50	11.47	11.44	11.42	11.39	11.36	11.34	11.31
10	11.28	11.25	11.23	11.20	11.17	11.15	11.12	11.10	11.07	11.04
11	11.02	10.99	10.97	10.94	10.91	10.89	10.86	10.84	10.81	10.79
12	10.76	10.74	10.72	10.69	10.67	10.64	10.62	10.59	10.57	10.55
13	10.52	10.50	10.47	10.45	10.43	10.40	10.38	10.36	10.34	10.31
14	10.29	10.27	10.24	10.22	10.20	10.18	10.15	10.13	10.11	10.09
15	10.07	10.04	10.02	10.00	9.98	9.96	9.94	9.92	9.89	9.87
16	9.85	9.83	9.81	9.79	9.77	9.75	9.73	9.71	9.69	9.67
17	9.65	9.63	9.61	9.59	9.57	9.55	9.53	9.51	9.49	9.47
18	9.45	9.43	9.41	9.39	9.37	9.36	9.34	9.32	9.30	9.28
19	9.26	9.24	9.23	9.21	9.19	9.17	9.15	9.13	9.12	9.10
20	9.08	9.06	9.05	9.03	9.01	8.99	8.98	8.96	8.94	8.92
21	8.91	8.89	8.87	8.86	8.84	8.82	8.81	8.79	8.77	8.76
22	8.74	8.72	8.71	8.69	8.67	8.66	8.64	8.63	8.61	8.59
23	8.58	8.56	8.55	8.53	8.51	8.50	8.48	8.47	8.45	8.44
24	8.42	8.41	8.39	8.38	8.36	8.35	8.33	8.32	8.30	8.29
25	8.27	8.26	8.24	8.23	8.21	8.20	8.18	8.17	8.16	8.14
26	8.13	8.11	8.10	8.08	8.07	8.06	8.04	8.03	8.01	8.00
27	7.99	7.97	7.96	7.94	7.93	7.92	7.90	7.89	7.88	7.86
28	7.85	7.84	7.82	7.81	7.80	7.78	7.77	7.76	7.74	7.73
29	7.72	7.70	7.69	7.68	7.66	7.65	7.64	7.63	7.61	7.60
30	7.59	7.57	7.56	7.55	7.54	7.52	7.51	7.50	7.49	7.47

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METHOD 2 (Using the Titrator Kit)

A titrator is available which allows the Biological Oxygen Demand to be recorded in the field. This eliminates the need for elaborate calculations. The instructions which accompany every titrator will direct you as to its use. However, a few points will be made here:

(a) the titrator is similar to a 'gun'; it possesses a digital counter which reads the concentration of titrant used in mg/litre. It also has a delivery knob which controls the titrant flow. Most titrations will take between ten and thirty turns.

(b) A titration cartridge is positioned at the front of the 'gun'. This contains high strength, pre-standardised titrating solution. Finally a delivery tube is attached to the cartridge which ejects small droplets of titrant into the sample. The delivery tube is calibrated so that the same size droplet is formed at the end of the tube each time.

(c) Various 'pillows' (small sachets) of chemicals are added in turn to the water sample (follow the instructions). Different chemical reactions will occur. When the solution is colourless, the full reaction has been completed.

(d) Read the number of digits from the counter windows. Divide the reading by 100 to determine the concentration of dissolved oxygen (in mg/litre).

Other tests, besides the dissolved oxygen test, may be performed with the acid of the 'gun' titrator using different chemicals, titration cartridges and delivery tubes. These include the hardness test, carbon dioxide text, alkalinity test and an acidity test. Therefore, the titrator is very efficient and versatile.

All the appliances are included in the Hach Digital Titrator Kit which, here in Ireland, can be ordered from Celtic Supplies in Dublin, at a cost of approximately IR£100. A year's supply of chemicals costs the same.

Points for Discussion

Factors affecting oxygen concentration and availibility.

Other factors necessary for plant and animal growth in an aquatic habitat.

The effect of pollution (natural or man-made) on the oxygen concentration of the habitat.

INVESTIGATION NO. 20 * LAKE DESCRIPTION

Introduction

Lakes are the biggest land-locked aquatic habitats in Ireland. They range in size from small ponds to the impressive Lough Neagh. Their nutrient status ranges from being very poor to moderately rich to very rich.

In this investigation you will choose a lake and describe as much of it as possible. The investigation is divided into different sections, each with a different aspect of the habitat which in reality are inter-related.

Equipment

To describe the lake you will need:

(i) a map (Ordance Survey map of the area)
(ii) paper and pencil

To identify the vegetation in and around the lake you need:

(iii) identification guides (See Bibliography)
(iv) record sheets
(v) nets - plankton and water net

To identify the fauna in the lake you need:

(vi) identification guides (See Bibliography)
(vii) collecting jar
(viii) water net
(ix) binocular microscope and petri-dishes in laboratory

To record the temperature (air and water) you will need:

(x) a thermometer
(xi) notepad and pencil

To test the clarity of the water you will need:

(xii) a secchi disc on a marked length of twine
(xiii) a boat or a canoe

Procedure

(1) Firstly, write up a description of the lake, its grid reference and height above sea level. Make a rough drawing, to a scale sufficient to show trees, nearby vegetation and any other points of interest.

(2) Identify the free floating and emergent vegetation present, at least those mentioned in this booklet.

(3) Plankton, the minute organisms (like waterfleas) that are free swimmers and dependent on the current for their location, can also be examined. If you wish to identify the plankton present, use the following routine with the plankton net.
Take the same number of sweeps in the same time period, e.g., 7 sweeps in 6 minutes. (Don't sweep too quickly or the force will push the plankton out through the mesh.) Record the result of the identification.

(4) For the identification of the fauna you firstly sweep along the shore with a freshwater net and collect the organisms. (For the best results you should disturb the detritus on the lake bed and walk slowly along the shore, sweeping the net along.) An area with some vegetation present is the best to choose as a lot of fauna should be present there.

(5) Place the organisms in a collecting jar and identify them if possible. If this is not possible, then return with them to the laboratory and identify them using the binocular microscope and some selected guides.

(6) Record the air and water temperatures. It is best if a max. - min. thermometer is used and if the temperatures are recorded a few times. If these are not available, then the ordinary thermometer may be used.

(7) A secchi disc is used to test the clarity of the water. It is a circular piece of aluminium which is divided into eight segments. Each alternative segment is painted black while the other segments are white. The diameter of the disc is 20cm.
Travel out into the lake to make a recording.
Take care, and wear a lifejacket if you cannot swim!
The method to follow is easy.
Gently lower the disc and watch the black and white areas.
Record the depth at which both the black and white segments can no longer be seen. This is a measure of the clarity of the water when compared with other areas and with standardised results. A particular recording can be substituted and then seen as a record of water clarity.

Results

Construct a food chain/web for the lake from your information, i.e., a food chain should be:

Plankton
↓
Insect Larva
↓
Water Beetle
↓
Fish

List the characteristics of the lake's temperature, clarity etc.

List the plants and animals (including plankton) found.

Draw a selection of plants and animals.

Points for Discussion

The difference in temperature between air and water.

The clarity of the water and its influence on the productivity of the lake.

The effect of recent weather conditions on the lake, e.g., wind causing ripples - effect of ripples on the lake.

Is the lake level lower/higher than normal?

Is ice present? (How thick is it / how much is present?)

The adaptations of the plants and animals to the aquatic habitats.

The zonation of the plants.

INVESTIGATION NO. 21

* TO DETERMINE THE RATE OF FLOW OF A STREAM AND ITS INFLUENCE ON FAUNA PRESENT.

Introduction

The rate at which a stream flows is very important as it has an effect on the type of organisms found in that stream. The organisms present in the stream have adapted to this mode of life. The easiest way to see these specialised invertebrates is to lift a stone and examine any present there. Flatworms and the larvae of stone and caddis flies will generally be found. In some streams, freshwater sponges may be found. These are found at the outlets of lakes where the flow of water is fast and a constant supply of nutrients is available.
Determine the speed of the stream using some simple equipment, and identify the fauna present.

Equipment

To calculate the flow rate of the stream the following apparatus is needed.

(i) an orange

(ii) a stop watch or an ordinary watch

(iii) a measuring tape

To identify the fauna you will need:

(iv) collecting bottles and labels

(v) guides (See Bibliography)

Procedure

RATE OF FLOW

Any of the many streams in the area may be used to calculate the flow rate. Select a number of streams.
Place the tape along a stretch of unhindered stream and mark off a length on the bank (approximately 2 to 10 metres).
Put the orange into the stream and time its progress over the marked length of stream.

Flow rate (cubic metre/second) = $\frac{W D C L}{T}$

Where W = average width in metres
D = average depth in metres
C = a constant (0.9 for smooth sand - 0.8 for rocky bed)
L = length of stream used in the test (metres)
T = time in seconds taken by the orange to travel the distance.

Substitute your own figures into the formula.

B. COLLECTION OF INSECTS.

Any of the streams selected may be used to find the aquatic fauna. Simply lift the stones and look at the fauna. If you cannot identify them at their present location, collect them and put the specimens in the bottles with some water from the stream. Remember to label them correctly, i.e., when and where collected, etc.

Results

Note the rate of flow.

List the fauna present in the stream - particularly those found higher up and lower down in the stream.

Points for Discussion

The factors influencing the flow rate of the stream.

The seasonality of the stream - flow rate in winter/summer.

Adaptations of organisms to their way of life.

Any differences between the lake and river organisms.

The location of sponges.

Their feeding habit in relation to their location.

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INVESTIGATION NO. 22 * BENTHOS SAMPLER

Introduction

Many aquatic organisms attach themselves to plant material in a lake. To duplicate this, place some 'landing platforms' out in the lake near some vegetation. The landing platform replaces the plant material, it can be a glass slide, timber or other equipment. These are called Benthos samplers: the aquatic fauna will attach themselves to these in the same way that they collect on the real vegetation.

Equipment

You will need:-

(i) a Benthos sampler - glass slides, timber

(ii) binocular microscope and petri-dishes

(iii) notepad and pencil

(iv) identification guides (See Bibliography)

(v) collecting bottles and labels

Procedure

(1) Record the precise location where you placed the sampler.

(2) Return to the area after a number of days and collect either (i) the sampler or (ii) the fauna of the sampler.

(3) Take these to the laboratory, remove any organisms present from the sampler.

(4) Identify the fauna, record them and return the organisms to the lake.

Results

List the animals found on the samplers.

Points for Discussion

Principal animals found on the samplers.

The most abundant animal found in the survey.

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Other Suggested Investigations

* Calculate the lake area from a large scale map.

* Determine the hardness of the water in the rivers and lakes.

* Complete a survey of a stream from its source to its end (entering lake, etc.). Describe its flow (flow rate), direction, colour of water, the plants and animals present at various stages. Sketch the stream, placing the most prominent plant/animal found in it at the proper sites.

** Identify flying adults of the larvae found in freshwater habitats. Floating traps (small muslin covered tents approx. 0.5 X 0.5m) may be put out to catch emerging insects. Alternatively, on a summers day, a sweep net may be used to catch the adult insects as they fly around the lake edge.

INVESTIGATION NO. 23 * THE HEIGHT OF A TREE

Introduction

The height of trees in a woodland may indicate the regeneration of that wood in the past. The height of a tree may be determined in a number of ways with various pieces of equipment. Different methods are outlined in the Techniques section of the book.
The purpose of this investigation is to determine if the trees present in the wood are of a uniform size and if regeneration is taking place.

Equipment

The equipment needed will depend on the method of height measurement chosen. For example a Hypsometer or a Clinometer can be used. Refer to the Techniques section, "Measuring Tree Height".

To measure the diameter at breast height you need:

(i) a measuring tape

(ii) notepad and pencil.

Procedure

It is best to select trees for measurement that are near the edge of the wood or trees that are near a clearing in the wood.
Measure the girth or diameter of the trees to obtain the diameter at breast height (D.B.H.).

Results

When the results of your measurements have been recorded, the age of the tree may be determined by using the following graphs.
Using the D.B.H., draw a horizontal line from the y axis and estimate the age of the tree.

Points of Discussion

Regeneration in the wood.

% saplings present.

Factors influencing regeneration.

INVESTIGATION NO. 24 * SEASONAL CHANGES

Introduction

Nothing in nature is constant. Plants grow, reproduce and die. Animals have a similar existence. However, many cycles are controlled by the seasons, while others continue throughout the year at an almost regular rate.
In this investigation, examine the changes which happen throughout the year. This may be performed using a single tree or plant or the whole wood.
This is largely descriptive. However, some measurements need to be taken. The investigation is most useful as it allows a plant's or area's history to be traced over a year with all the changes that the seasons entail.

Equipment

For this investigation you will need:
(i) identification guides (See Bibliography)
(ii) a maximum-minimum thermometer
(iii) lightmeters
(iv) swirling hygrometer
(v) rainfall container

Procedure

(1) Select one plant or habitat. Clearly mark its location on a map of the area. For example, if you select a tree, identify it first.
(2) Then describe its condition in the present season, i.e., whether it possesses leaves or not and other variable characteristics. Then describe the non-variable characteristics, such as bark, colour, etc.
(3) Visit the tree at least once each season to discern the changes that have occurred to it over that period of time.
(4) If you select a habitat, record the general features of that habitat, i.e., the plants that are present, whether they are in flower or not, if buds are present, etc.
(5) Once the general appearance of the habitat is recorded, you can become more specific by listing the plants present and their stage of development.
(6) Then you can record the variable characteristics such as temperature, humidity, rainfall and light (using methods stated previously), for each season.
(7) Visit the area at least twice each season (if possible).

Results

What changes have you noticed:-
(a) between the seasons?
(b) over the year for the plant/habitat you selected?
What cycles would remain fairly constant through the year?
Could you describe any of these?

Points for Discussion

The seasonality of habitats and their plants.
The influence of environmental factors on plants.

INVESTIGATION NO. 25 ** BIRD PELLETS

Introduction

Some smaller birds, members of the crow family, and birds of prey regurgitate indigestible matter as pellets. Such pellets contain different organic materials but mostly hair, feathers, bones, chitin and indigestible plant matter. They are best known as owl pellets which grow grey on drying. When dismantled, these will clearly show what the bird has consumed.

This habit of regurgitation is quite healthy and normal and should not be confused with animals vomiting food which has irritated their stomach.

Birds of prey pellets contain few bones since they are able to digest these. Crows produce a very loose pellet containing all kinds of material due to their scavenger habit of eating. They include grasses, shells and little stones. Pellets may be found in many locations but most owls drop them from their roosting places. For example, the barn owl drops them in churches, ruins, etc. They may also be found below look-out places such as a fence post.

Bird pellets generally come under the heading of owl pellets, possibly because it is easier to find these than to see the bird.

Equipment

For this investigation you will need:

(i) collecting bags and labels

(ii) record sheets

In the laboratory you will need:

(iii) a white tray

(iv) an identification guide. (Miles, M. 1952. The Entomology of Bird Pellets, The Amateur Entomologist Society, Leaflet No. 24; Yalden, D.W., 1977. The Identification of remains in Owl Pellets. Occasional Publication of the Mammal Society.)

Procedure

(1) Collect some bird pellets in the bags. Label with the date and the number collected.

(2) Look around the area, record its appearance, i.e., ruins, wood. Look above for signs of nests or birds. Record any other information that may give a clue as to the type of bird that produced the pellet.

(3) In the laboratory, dismantle the pellet carefully on a white tray, placing all the bones/cartilage to one side and all the plant material (if any) to another side. Hair should be put on the same side as the bones.

(4) Once the pellet has been completely dismantled, transfer the plant material to a bag for later identification.

(5) Sort through the bones and try to complete the skeleton of the prey. Use the guide to help you identify the animals.

(6) Photograph or sketch the skeleton on the tray. Place a ruler beside the animal to show the size of the prey.
A catalogue of the various prey found in pellets from different species of bird may be built up in this way.

(7) Sort through the plant material and try to identify it. This will be more difficult to perform because the tissues will be partly digested. List what is identified.

(8) A record of prey/plants in the diet of different bird species may be made.

Results

These consist of photographs/sketches of prey and/or lists of plants present in the pellets.

Points for Discussion

Location of pellets - roosting places, look-out posts, etc.

Diet of birds determined from analysis of pellets.

INVESTIGATION NO. 26

* ENGLISH NAMES FOR LICHENS AND MOSSES

Introduction

Lichens and mosses, some of the simplest plants, do not have very simple names. In fact, most of them have Latin names which originate from their scientific names. Therefore, it is up to you to identify them and place your own name on them.

Equipment

You will need:

(i) guides (See Bibliography)

(ii) collecting bags and labels

(iii) notepad and pencil

Procedure

(1) Identify a number of lichens and mosses with the guides.

(2) Alternatively, you can collect them and identify them later.

(3) When this is completed, give them an English name, either the common one or one which you make up.

(4) Also, make a table with both the Latin and English names so that you can check samples whenever necessary.

(5) Photographs can also be used as a record of these.

(6) These English names can then be used in other fieldwork projects, making it easier for you to record their presence.

Results

Your record now becomes the result of the search.

Points for Discussion

Where were the lichens more common?

Which types were more abundant?

Distribution of the lichens.

INVESTIGATION NO. 27 * TRACKING

Introduction

Animals leave various signs of their presence in an area after they have moved on. These include dung and footprints. In this investigation you will make a cast of any animal footprints that are found in the area. In this way you will have a proper record and it will help in identifying the animals more easily and more quickly in future field trips.

Equipment

You will need:

(i) plaster of paris

(ii) trowel

(iii) cardboard and labels

(iv) plastic bag

Procedure

(1) Select a number of complete tracks in a muddy site.

(2) Make detailed sketches of the tracks including their dimensions.

(3) Fix a card around the complete print.

(4) Pour the plaster gently into the mould.

(5) Dig up the hardened cast (in the card) and the surrounding mud.

(6) The raised cast can be inked or painted to make prints on paper.

(7) Store the casts in a drawer or a cardboard tube.

Points for Discussion

To what animal do your prints belong?

Are these tracks common?

Have you found any unusual prints?

INVESTIGATION NO. 28 ** TROPHIC LEVELS IN ECOSYSTEMS

Introduction

Plants are the basic food producers in any ecosystem. They produce food in the form of plant tissue with the aid of light and the process of photosynthesis. This is eaten by animals known as herbivores (or plant eaters) which are the primary consumers. These convert the plant tissue into animal tissue. These are, in turn, eaten by other animals called carnivores (or meat eaters) which are the secondary consumers. These may, in turn, be eaten by bigger carnivores or tertiary consumers.

When plants or animals die, they are attacked by saprotrophs (bacteria and fungi usually). This degraded material is then consumed by detritivores (detritus feeders) or else it replenishes the soil with nutrients to allow continued plant growth to start the whole cycle again.

Each of these steps are delicately balanced in any community of plants and animals. A balance exists between the growing, the eating and those being eaten in the food cycle. The whole process is called the trophic structure, while each step is a trophic level.

In this investigation examine two aspects of trophic structure; foodchains (and webs) and biomass.

Equipment

To perform the biomass calculation for this investigation, you will need:

(i) a 0.25 m^2 quadrat

(ii) clippers and trowel

(iii) oven at 95°C

(iv) scales

(v) collecting bottles, bags and labels.

Procedure

FOODCHAINS:
Using the results of a general survey of the ground layer, the leaf litter and the soil samples, find out by what each plant is eaten. Then determine by what each animal is eaten. (Observation can be used but you may also refer to books.) Prepare a few food chains and then draw a web.

BIOMASS:
Biomass is the weight of living matter. Whereas food chains show the links in a habitat, biomass is the quantitative aspect of a food chain.
Place a 0.25m^2 quadrat in the habitat.
Clip inside it, retaining all materials within the quadrat but leaving behind branches enclosed by the quadrat but rooted outside.
Sample for animals and collect any present (it is not necessary to preserve them).

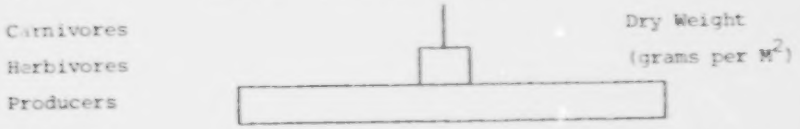
Oven dry the plant material at 95°C for 24 hours (lay it out on an oven tray).
Weigh after this period and express as dry weight per square metre.
Dig the area enclosed by the quadrat, collect the roots, wash the soil off and dry the roots.
Weigh, using the above method.
Add the two figures to give the total biomass.

Divide the animals into primary and secondary consumers. (Tertiary consumers such as mice, birds, etc. usually only visit the area and cannot be recorded.)
Weigh the groups of animals.

Results

Construct an Eltonian Pyramid. This is the method of displaying biomass.

Fig. 44. ELTONIAN PYRAMID



Alternatively, do not dry the plant material, this gives the gram wet weight per square metre.
It is best to perform this in different habitats and even in different areas within the same habitat for comparative processes. Usually the differences between an enclosed area and the surrounding area is tested. It may therefore be used with the investigation on exclosures.
Areas may also be sampled at different times.

Usually the difference between plant and animal biomass is enormous. Why? Could larger animal populations be established and survive?
Is there any area where animal biomass exceeds the plant biomass? Why is this the case here?

Points for Discussion

Discuss biomass.

Discuss energy flow in relation to the Eltonian pyramid.

INVESTIGATION NO. 29

** THE DISTRIBUTION OF HAIRY AND GLABROUS (HAIRLESS) FOXGLOVES (DIGITALIS PURPUREA)

Introduction

The occurence of two forms or variants of the same plant species is termed polymorphism. There must be a good reason for the occurrence of such variants. An example of such a phenomenon is the hairy and glabrous foxgloves. The biological explanation for the presence of these variants is genetic, the mode of inheritance is simple - a single gene, hairy dominant.

Equipment

This investigation is performed under various headings. These include the environmental and edaphic (soil) conditions of the plant.
For this you will need the following equipment:
(i) collecting bags and labels
(ii) trowel
(iii) lightmeter (luxmeter or integrated lightmeter)
(iv) notebook and pencil

Procedure

(1) It is best to perform this in June or July, as the characteristic is best seen then. Those plants with the hairy gene are easily distinguished by the thick 'pelt' of hairs on the stems and the petioles of the rosette leaves, which appear darker with a red stem.
(2) To discover the differences in distribution most of the environmental and edaphic factors should be examined. Measurements can be taken of the following conditions: light, soil pH and moisture content, etc.

By answering the following basic questions, the pattern of distribution could be plotted:

(a) Where do the plants grow?

(b) Do the two forms occur together? If so, in what ratio?

(c) Is there a soil difference (more acid, wetter, rocky) in the distribution?

(d) Are the areas where the plants are found, different in any way (well vegetated, disturbed)?

(e) Has light any influence on distribution (measure with a luxmeter or an integrated lightmeter)?

(f) Do the hairy stems give the possessor any advantage?

Results

Tabulate the results, stating the location of each foxglove and the physical conditions (light, soil, etc.) which accompany it. Use other methods such as graphs,

histograms, etc. to show the results where possible.

The Peppered Moth **(Biston betulana)** is another example of polymorphism. It was demonstrated by experience that the distribution of the moth which has two forms, normal and mutant, was related to selection factors.

Could the foxglove be under the same influence?

What do your results suggest?

Are the differences great or slight as regards distribution?

Do you think any one form is dominant over the other?

Is the genetic factor likely to have a long-term effect on the proportions of the two types in any population?

This investigation deals with certain evolutionary concepts, such as selection and population genetics. Can you explain what you have discovered in terms of these concepts.

Points for Discussion

Discuss selection and population genetics in general.

Relate what you have discovered about the foxglove and this investigation.

Find out what other types of polymorphisms exist.

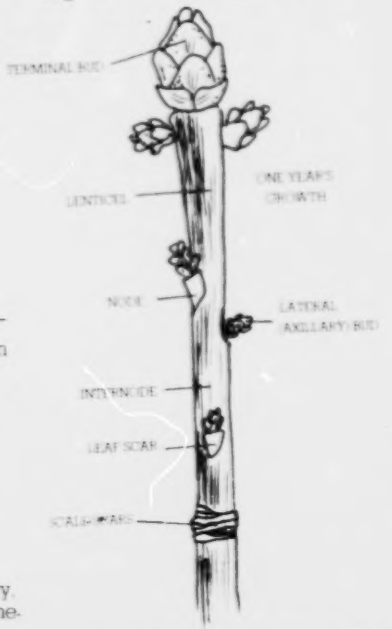
INVESTIGATION NO. 30 * TWIG COLLECTION

Introduction

Deciduous trees shed their leaves during autumn and then, in spring, they grow rapidly producing new leaves. The region of the tree that produces this growth is the twig. Each twig has buds which are the growth regions for new leaves. (Fig. 45)

Twigs can be used as an identification tool for trees and in this investigation, a number of different twigs are collected to produce a key. Using this key, you can identify the tree by its twig type.

Fig. 45 A WINTER TWIG



Equipment

You will need:-

(i) a tree guide (See Bibliography)

(ii) a large sheet of paper

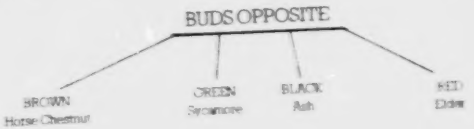
(iii) glue (or other adhesive material)

Procedure

(1) Collect a number of intact twigs from various tree species. Identify the following parts:-
   (a) Terminal bud
   (b) Axillary bud
   (c) Lateral bud
   (d) Leaf scar
   (e) Ring scar
   (f) Vein scar
   (g) Lenticels
   (h) A year's growth.

(2) Describe the characteristics (i.e., hairy, sticky), colour and arrangement of the buds, i.e., opposite/alternate, etc.

(3) Produce a key from this information (ask your teacher for help if necessary or refer to some books). For example, when all the information is collected, construct a simple key like this:



Points for Discussion

Construction of keys.

The usefulness of keys.

INVESTIGATION NO. 31 * EXCLOSURE EXPERIMENT IN HEATHLAND

Introduction

Exclosures are used as a method of studying the effect of grazing by large animals on areas of vegetation. They may be constructed on a large or small scale. In Killarney National Park, a large exclosure was built to show the effect of grazing by sheep and deer on the area. The difference between the enclosed area and the area around it is quite extraordinary but this exclosure is in existence for over 7 years.

The idea behind the exclosure is to exclude the grazers from the area and to allow it to regenerate without any influence from these animals.

Examine the vegetation present inside the exclosure as well as outside, to determine whether the exclusion of the animals has had any influence on the size, amount and type of plants inside/outside.

Equipment

It is best to visit this area once or twice a year. You will need:

(i) a notepad and pencil

(ii) quadrats (0.5m X 0.5m)

(iii) guides (See Bibliography)

Procedure

(1) Visually examine the area inside and outside the exclosure.

(2) Then randomly throw the quadrat over your shoulder into the exclosure.

(3) Give a cover value to the plants inside the quadrat.

(4) Perform this 5 or 6 times.

(5) Note all the results and check them with previous records.

Results

Tabulate your results.

What plants are in greater abundance?

Do grazers have an influence on plant growth, relating the answer to the results obtained?

What are the main grazers in the area?

Is there any way to control the influence of these grazers? Should this be attempted?

Points for Discussion

Grazing pressure on areas.

The benefit of exclosures to plants.

INVESTIGATION NO. 32 * RECORDING TEMPERATURES

Introduction

Temperature is only one of the many factors which influence the distribution of flora and fauna within an area. Different habitats, within a small area, can have substantial temperature differences.
In this investigation, record the temperature in a number of different habitats and discuss their influence on plant and animal life.

Equipment

To record the temperature, the following equipment is necessary:

(i) a maximum-minimum thermometer (the plastic cased types sold in horticultural shops will suffice);

(ii) a notepad and pencil.

Procedure

(1) Place one max. - min. thermometer at three different sites, for example:
one can be placed in a small stream;
one can be put on a tree near a wood;
one can be located in the lake.

(2) Record the readings a few times, well spread over the year.
(Perhaps two or three times per person for an accurate record.)

Results

Tabulate your results to show the trend of temperature fluctuations over the seasons for each area examined.

Points for Discussion

The differences in temperature throughout the season.
The differences in temperatures for the various areas, i.e., atmospheric and aquatic sites.
The influence of temperature on flora and fauna in each area.

INVESTIGATION NO. 33 * WATER pH

Introduction

Water pH is determined by the base rock of the area over which a river flows. Therefore, rock of a limestone nature creates a basic condition in a lake, while sandstone results in an acidic pH in the lake.

This factor influences the flora and fauna which can inhabit the aquatic situation. For this investigation test the pH of various aquatic habitats from bog pools to larger lakes and relate the results to the flora and fauna which are in or near the aquatic sites sampled.

Equipment

The easiest way to test the pH in the field is with some litmus paper. You will need:

(i) some Universal Indicator paper

(ii) notepad and pencil

Alternatively, you can collect some samples and test them in the laboratory. For this you will need:

(i) plastic water bottles

(ii) pH meter

(iii) notepad and pencil

A sample can be tested in both ways to find the accuracy of the litmus test.

Procedure

(1) If using the Universal Indicator paper, dip it into various aquatic situations and wait a few seconds.

(2) Remove it and compare with the chart of colours provided.

(3) Record the pH value.

(4) Alternatively, the pH meter is simply dipped into the water sample (once it has regulated at a pH of 7 previously). Record the value.

(5) A variety of aquatic habitats should be tested, such as bog pools, streams flowing into and out of lakes, lakes in different areas, Sphagnum bogs, marshy area, etc.

Results

Tabulate the results.
Which areas were the most acidic or basic?
What could you say about the geology of the area from the results?
What flora was present around the sites sampled? Are they characteristic for the pHs found in the sites? If not, why not?
Why are the Sphagnum areas acidic? What influence does this have on decomposition in the area?

Points for Discussion

Discuss the influence of pH on flora and fauna in the aquatic habitat.

INVESTIGATION NO. 34 * THE EXAMINATION OF FISH SCALES

Introduction

Scales are a special type of skin which on the majority of modern fishes are usually thin and flexible in comparison to the stout armour of bony plates possessed by the primitive fishes. As such, they offer only moderate protection to the fish, but the different fish families have become adapted to new ways of protection, spines on the puffers, for instance, when packed close together and thickened can provide a tough outer covering to the fish.

The scales can also be read, like the tree rings, to determine the age and growth of a fish. In this investigation examine some fish scales and estimate the age of the fish from which these came.

Equipment

This investigation requires some chemicals which should be handled with care. These are:

(i) Potassium hydroxide (4%) and
(ii) Glycerine.

You will also need:

(iii) a low power microscope
(iv) clean slides.

This investigation can be performed in conjuction with the one on the examination of the stomach contents, and the scales can be removed from these fish.

Procedure

(1) Remove a number of scales from the fish.
(2) Clean them in the Potassium hydroxide.
(3) Mount them in some glycerine on the clean slides.
(4) Examine the scales under the low power microscope.
(5) Sketch the scales.
(6) Try to count as many rings as possible. Experience will help in the identification of the rings.

Results

Note your results.

How old were the fish that you examined?

Points for Discussion

The age of the fish examined.

INVESTIGATION NO. 35 ** EXAMINATION OF FISH STOMACH CONTENTS

Introduction

Irish lakes have long been known for their fish, particularly stocks of salmon (**Salmo salar**), brown trout (**Salmo trutta**) and sea trout (**S. namaycush**). Char (**Salvelinus alpinus**), a relative of the salmonids, may also be present. In this investigation, dissect a fish and examine the location of the internal organs and the contents of the stomach.

Equipment

If one of your hobbies is fishing, then you can catch the fish for yourself. You might need a boat. For this you will need the usual fishing tackle and protective clothing.
Alternatively, you can buy the fish from a local fisherman.
For the dissection, the following materials will be necessary:

(i) dissection kit

(ii) board

(iii) binocular microscope

Procedure

(1) Examine the external features of the fish first, i.e., jaws, teeth - what types present? Fins - are they paired and how are they supported? Tail - what shape is it? Gills - how many and are they covered? Skin - what colour is it? Scales - what type present?
(2) Carefully cut along the underline of the belly.
(3) Open out the fish and examine the internal organs. Look for the following:
   (a) alimentary tract
   (b) swimbladder
   (c) urinary system
   (d) genital system
   (e) circulatory system.
(4) When all of these have been found and examined, remove the stomach and open it with the scalpel.
(5) Extract the contents from the stomach and examine them. It may be necessary to use a binocular microscope to identify the organisms.
(6) List the organisms present and their number.
(7) If more than one fish species is dissected, compare the diets of the fish.

Results

Draw a food chain in which the fish is the final consumer.

Points for Discussion

The adaptation of the fish to underwater life.
The main constituent of fish diet.
The different diets of different fish.
If you examined the stomachs of two fish (of the same species) from two different lakes, do you think their diets would differ a great deal? (Why not try this as an investigation?)

CAPPANALEA OUTDOOR EDUCATION CENTRE, CARAGH LAKE, CO. KERRY.

This section of the booklet deals specifically with the Cappanalea Outdoor Education Centre in Kerry.

A geological description of the area is given here. The habitats are similar to those already described, any of the plants or animals mentioned earlier may be found in this area.

Plants and animals unique to this area are described and should be noted. Special investigations for this area are also contained in this section.

When you arrive at Cappanalea O.E.C., whether for a day course or a few days, you should avail of the full facilities at the Centre. In this way, the group may take a new look at the outdoors. Certain educational objectives can be met while the pupils enjoy themselves through a new learning experience. They should also leave with a greater appreciation of their natural environment and an understanding of the need for conservation of this valuable resource.

Cappanalea Outdoor Education Centre, (O.E.C.), is situated near Caragh Lake, approximately 13km west of Killorglin (V726898). The Centre itself (buildings, etc.), is a relatively new development but the area had previously functioned as a location for outdoor activities. The Killorglin Community Council purchased the site 12 years ago, using it as a base/campsite for such activities.

Shortly afterwards, A.F.A.S. Munster (Association For Adventure Sports) participated with the Community Council in the further development of the area. Then in 1981, the site was sold to County Kerry Vocational Education Committee (V.E.C.) on the condition that it would be developed as an outdoor education centre. Such development continued with the construction of a building accommodating up to 48 people which was completed in 1982. The project was jointly funded by the E.E.C. and the Kerry V.E.C. The Centre now encompasses approximately 55 acres, including rented acreage. Also in 1981, Mr. Donal Dowd was appointed Manager of the Centre and a field studies guide was published by Dr. John Breen and Mr. Tom Harrington, of Thomond College of Education, Limerick.

The management committee of the Centre would hope that more students would use the facilities. To promote this, more in-depth courses are planned, as well as greater variety in the courses.

Outdoor education is of the utmost importance in today's highly automated society. It is a means by which people can become aware of their natural environment with its recreational advantages. Also, through field studies, people may appreciate the need for conservation of this environment with its delicate ecological relationships in which we too play a vital role.

What better setting is there for an outdoor education centre than the Cappanalea area, the beauty of which has been noted:
"This is one of the choicest spots in the country for salmon and sea trout, walking and mountaineering." (Hayward, 1970 - In the Kingdom of Kerry)

GEOLOGY AND HISTORY

Cappanalea derives its name from the Irish 'Cappach na Lea'. The direct translation is ambiguous as it may imply either an area of stones or an area of flowers. However, the adjoining area incorporating Caragh Lake is remarkably rocky, and this would suggest that the former explanation for the name is more appropriate.
The vegetation that now exists in the area is influenced by many factors which include the area's geology, history and climate.
Cappanalea Outdoor Education Centre is located on high ground on the east side of Caragh Lake. The area surrounding the Centre consists of mountain ridges and peaks intersected by valleys. The majority of these peaks are over 900m. The present rugged landscape was sculpted by the last Ice Age, approximately 10,000 years ago and the bedrock in the vicinity is Old Red Sandstone (O.R.S.), laid down by a process of erosion and deposition, about 350 million years ago. During this Devonian period, arid conditions prevailed around the lakes and the sandstone was formed in freshwater lakes. The dominant red and the lesser purple colours are present as a result of iron oxides. O.R.S. occurs widely in Munster.

The mountain ranges (McGillycuddy Reeks, Caha Mountains and the Maharee) which encircle the Centre were formed during the late Carboniferous period by the Hercynian (Armorican) folding. This folding can now be traced eastwards to Dungarvan and west to Dingle Bay along the Armorican Front.
The last Ice Age, which was a major contributor to the present shape of the area, occured during the Pleistocene period which lasted for about one million years. The main influence during this stage was the Cork-Kerry glaciation, which had its centre in Kenmare. Glaciers in the local area created the deep U-shaped valleys through which the Caragh and Laune Rivers now flow. A thick spread of boulder clay over the rock also remained allowing the formation of Cappanalea lake, as well as the other lakes in the area.

Post-glaciation history includes the formation of the blanket bogs and the podzolised soils in the area.

The Cappanalea soils originate from three types of parent material - O.R.S., boulder clay and blanket peat. These parent materials are moderately poor to poor in bases, giving an acid character to the soil. The in-situ degradation of O.R.S., through elevation and leaching, produces a soil inherently poor in nutrients and of an acid nature. When this leaching occurs, an iron pan is usually formed in the subsoil due to accumulation of the iron oxide. This prevents root penetration and such areas are used for forestry purposes. Blanket bogs occur to the north and the south of Caragh Lake, while poorly drained areas around Cappanalea lake have allowed the establishment of a marshy area dominated by Sphagnum mosses.

People have also had an influence on the area which is clearly seen in the vegetation. Cappanalea was more wooded in historical times than at present. Exploitation of the woods, particularly Oak, for fuel and clearance for agricultural purposes were probably the major factors responsible for the decline of woodland in the area. Smith (1774) wrote in his book "The Ancient and Present State of the Kingdom of Kerry" that most of the timber in the area had been felled for fuelling the ironworks at Blackstones on the Caragh River.
"The hills and mountains hereabouts were formerly covered with trees which have been destroyed by the ironworks ..... it seems a little surprising that Sir William Petty should not in his lifetime have taken care to preserve his woods, by copseing them as they were cut down".

These ironworks were still in operation up to 1774. This smelting operation almost certainly increased the population in the area. Remnants of stone houses and stone walls are visible throughout the whole area, and in certain places, traces of ridges and 'lazy beds' for potato cultivation can be seen. The famine in 1847 must have caused mass emigration from the area, leaving deserted fields to become invaded by gorse, bracken and other wild plants. These fields are now used for the grazing of cattle and sheep, while other land is used for limited forestry.

The climate of the area is mild oceanic. The mean annual rainfall in the vicinity is very high, 1,600 to 2,000mm, with more than 200 rain days each year. On the higher elevations the rainfall may be even greater.

The temperature range is small, when compared to other areas in the country and mainland Europe. Mean daily temperature for January is 6.5°C while in July it only rises up to 15.5°C. However, monthly fluctuations can be quite considerable in temperature and rainfall readings.

Below are some climatic diagrams produced from data taken during a period in 1984.
The influence that these factors, particularly the geology and climatic conditions, have had on the area is clearly visible in the type of vegetation now growing there. These have caused a luxuriance of mosses and ferns throughout the woods, the growth of non-nutritional grasses and the paucity of flowering plants.
Grazing is also an important factor in the present condition of the vegetation.

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LUSITANIAN FLORA AND FAUNA

This special type of flora and fauna is confined to the counties along the southwestern seaboard, in particular, but may also be found in some other western counties. The mild winter in these counties is likely to have influenced this distribution but an explanation as to how they originally arrived here is not as obvious.

The two current theories for this distribution are -

(1) that these plants and animals survived the last Ice Age in unglaciated 'refuges', along the west coast.

(2) that a land bridge connected the southwest of Europe and the southwest of Ireland about 12,000 years ago (as the sea level was lower than it is now). These plants and animals could have migrated via this land bridge.

No evidence at present points directly to either of the explanations - perhaps there is some truth in both of them.
The plants and animals are not to be found in Britain, they only exist now in Spain, Portugal, the western Mediterranean and the west of Ireland.

Plants present in this group from Cappanalea include St. Patrick's Cabbage **(Saxifraga spathularis)**, the kidney-shaped saxifrage **(S. hirsuta)**, the greater flowered butterwort **(Pinguicula grandiflora)**, while the animals present include the Kerry spotted slug **(Geomalacus maculosus)**.

Other plants belonging to this group found in the county are the Kerry Lily **(Simethis planifolia)** which is quite rare, the Irish spurge **(Euphorbia hiberna)** growing near wood-edges and river-banks (it also possesses poisonous properties), the strawberry tree or Arbutus **(Arbutus unedo)** which is common in the Killarney area, and the Recurved sandwort **(Minuartia recurva)**, located in the Caha Mountains.
The only other Lusitanian Fauna found in Kerry is the natterjack toad **(Bufo calamita)**.

Extra special care should be taken when viewing and examining any of these plants and animals as they have become adapted to their present environment. Any disturbance could cause death.

NOTE: An unusual bird in the area is the Chough **(Pyrrhocorax pyrrhocorax)** normally found nesting on sea-cliffs or areas nearer the sea. The Chough is a slim, red-billed, red-legged relative of the crow. In flight, the feathers of the wing are splayed out like fingers. Its distinctive call was responsible for the name of the bird.

Ants' nests can be found on sunny slopes. These are generally under flat stones which are used as solar panels to maintain the nests' temperature. A few mounds of the yellow ant **(Lasius flavus)** can be found near Caragh Lake. These are located at the Sphagnum marsh (alongside the river inlet from Cappanalea Lake). The mounds are solar panels for heating the nest. The mound has created a different microhabitat in which a number of plants thrive. This is due to the fact that the pH is different and the soil is drier and more open than the soil in the immediate vicinity of the nest.

DO NOT DAMAGE THE NESTS.

INVESTIGATION NO. 36 * BIRD IDENTIFICATION

Introduction

Birds are one of the most studied of all animals, possibly because of their flight and colour. Bird watching is a common hobby. It is a solitary hobby with patience required. In the Cappanalea area you will see one bird which is rare elsewhere - it is the Chough **(Pyrrhocorax pyrrhocorax)**. This is a member of the Crow family and has the unusual characteristics of a red beak and red legs. It also possesses an unusual call which christened the bird Chough (pronounced 'Chuff'). These birds are normally present along the coast and since Cappanalea is only a short distance from the coast (as the crow flies, of course!), they can be seen in the vicinity of the cliffs above Caragh Lake.
Other birds that are seen in the area include the Kestrel **(Falcus tinnunculus)** and Wood Pigeons **(Columba palumbus)**.

Equipment

To identify the birds you will need;

(i) a pair of binoculars

(ii) identification guides (a beginner should concentrate on obtaining a good bird guide)

(iii) a notepad and pencil (or a prepared record sheet).

Procedure

Birds can be identified in any area, but for the beginner it is best to stay outside of woods where large densities of birds are present.

(1) Select an area and get in a comfortable position.

(2) Remain as quiet and motionless as possible.

(3) When a bird comes into view, identify and note it as quickly as possible. Also make a note of the bird's activity, i.e., if it is feeding (what it is eating), courting, etc.

(4) Once you have become used to identifying the birds you can move into areas with larger populations.

Are there many different species present?

What are the most common birds in the area?

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BIRD IDENTIFICATION SHEET

Colour of Plumage	Size	Flight	Sex	Beak shape	Shape of feet	Colour of legs	When seen	Where seen	Nest (if visible)	Foods eaten	Bird species

Discussion

Birds present in the area.

Migratory birds present.

Diet of these birds.

Nesting birds.

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INVESTIGATION NO. 37 * LUSITANIAN FLORA AND FAUNA

Introduction

The Kerry area is world famous for its Lusitanian Flora and Fauna. In this investigation, try to locate and indentify the different types of the unique flora and fauna found in the Cappanalea area.

Equipment

For this investigation you will need to know:

(i) what the flora look like - COLLECTION OF THESE IS ILLEGAL.

(ii) what the fauna look like

(iii) the locations of these flora and fauna

(iv) guides (See Bibliography).

Procedure

To locate the greater flowered butterwort **(Pinguicula grandiflora)**, try the area near Cappanalea Wood where it meets the moorland. The best region is the wet area near the exclosure. It can only be found in spring, summer and autumn. The leaves disappear for the winter.

The St. Patrick's Cabbage can be found in Cappanalea Wood; the flowers appear in May/June. It may also be seen around the whole area in damper places.

The Kerry Spotted Slug is more difficult to locate as it only appears on very humid or wet days. It may be seen grazing the lichens on rocks all along the cliffs. (Beware - the common slugs sometimes occur in a spotted form.)

Points for Discussion

What would happen to these unique species if they were removed from here?

Why?

Why is the slug pigmented in this way it is?

INVESTIGATION NO. 38 * A SOIL PROFILE

Introduction

The soil profile refers to a vertical section of soil down to and including the geological material present (i.e., rocks). The nature of the soil is very important to plant growth because it influences root development, moisture storage and nutrient supply. The profile usually displays a series of layers that may differ in properties such as colour, texture, porosity, structure, consistence, organic matter content and chemical constitution. These different layers are known as soil horizons.
The type of soil around Cappanalea is termed a peaty podzol. Its horisons are divided as follows:

HORIZON	DEPTH(cm)	DESCRIPTION
02	25-0	Peat, black, plentiful roots
A2	0-10	Gravelly, sandy loam; grey; plentiful roots.
B21ir	10	Ironpan
B22ir	10-18	Gravelly, sandy loam; yellowish-red; few roots.
B3	18-30	Gravelly, sandy loam; reddish-yellow; few roots; moist
R	30	Old Red Sandstone bedrock.

The letters only represent the horizons; the B horizon is subdivided into various parts while the C horizon (usually present above is bedrock) is totally missing.
In this investigation, examine the soil in the area and identify the various horizons.
Soil profiles may be found at various locations around the Centre. There is one located just before you traverse the cattle grid, another is positioned on the road above the Centre.

Equipment

To perform this investigation you will need:

(i) to locate a soil profile
(ii) a measuring tape
(iii) a notebook and pencil

Procedure

(1) Locate a soil profile.
(2) Examine it carefully. Note the colour and the position of roots, stones, ironpan and horizons.
(3) Measure the various horizons and record these measurements.
(4) Make a rough sketch of the profile.

Points for Discussion

Podzolised soils are easily leached, i.e., their nutrients, minerals, etc., are washed out by water. What effect does this have on plant growth?
Podzolised soils are also of an acidic nature. Does this influence plant growth?
The cause of the ironpan and its effect on plant growth.
The distribution of roots in the profile.
The effect of this soil on the vegetation of the area.

INVESTIGATION NO. 39 * PROPERTIES OF SOIL

Introduction

Soil properties are very important as they influence the vegetation which is present on the soil. (Other factors, such as climate, also influence vegetation.) In this investigation determine the % organic content, % water content, pH, chemical composition and porosity.

Equipment

You will need the following:

(i) soil samples
(ii) bunsen burner
(iii) mortar and pestle
(iv) beakers
(v) soil testing kit
(vi) graduated cylinder
(vii) record sheets

Procedure

(1) Determine the % organic content and % water content using the procedure previously outlined in Investigation No. 16.
(2) Measure the pH using the universal indicator (Investigation No. 16) or the soil testing kit (available at the Centre).
(3) Assess the chemical composition of the soil sample for various minerals using the soil testing kit. This is available at the Centre and instructions are included.
(4) Calculate the porosity of the soil in the following way:
(a) place a known amount of soil in a graduated cylinder,
(b) add an equal volume of water,
(c) watch all the bubbles of air rise,
(d) allow it to stand for five minutes,
(e) measure the amount of soil now present in the cylinder,
(f) determine the porosity by using the following formula -

$$\frac{Sf}{Si} \times 100 = \%$$

Sf = Final Soil Volume
Si = Initial Soil Volume

$$\frac{80}{100} \times 100 = 80\%$$

Results

Tabulate all your results.
When comparing a number of sites, chart the results so that comparisons can be made.

Points for Discussion

The % organic matter content of the soil.
The % water content of the soil.
The pH of the soil.
The minerals present in the soil.
The porosity of the soil.
The influence of these factors on the vegetation growing on this soil.
The effect of these factors on the animals present in the soil.

INVESTIGATION NO. 40 * THE RESULTS OF GLACIATION

Introduction

The last Ice Age shaped the area around Cappanalea. It produced the U-shaped valley through which the Caragh River flows and in which Caragh Lake is situated.
In this investigation, examine the area around Cappanalea for the results of glaciation.

Equipment

For this investigation you will need:

(i) a notebook and pencil

(ii) a pair of binoculars

Procedure

Look for the following features.

(1) A coom (corrie or cirque) - a deep, bowl-shaped depression surrounded by cliffs except at the section facing down the valley. Many of these cooms are now occupied by lakes. The glacier formed in this hollow.

(2) When the glaciers were formed in adjacent hollows, the surrounding ground could have been undermined by frost-action from both sides - the cooms now present are separated by pointed ridges with a comb-like outline. These ridges are called arêtes.

(3) If the ground between the cooms has collapsed on both sides, a sag remains. This is called a col or saddle.

(4) Look at the valley of Carrauntouhil from the Caragh Lake side (this is the back route up the mountain via Caher). Sketch the glaciated valley and note the position of rocks, etc., in the valley.

Points for Discussion

Discuss the process of glaciation and ice erosion.
The glaciation of this area.
The influence of glaciation on soil in this area.

TABLE TO DETERMINE HUMIDITY VALUES FROM SWIRLING HYGROMETER

Dry bulb	Wet bulb depression (°C)																										
°C	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10	11	12	13	14	15	16
0	94	91	89	86	82	79	75	72	69	65	57	49	41	33	25	17	2										
1	97	93	90	86	83	81	77	74	71	68	60	52	44	36	29	21	7										
2	97	93	90	87	84	80	77	74	71	68	62	54	47	40	32	25	11										
3	97	94	91	88	84	81	78	75	72	69	62	54	50	43	36	29	16	3									
4	97	94	91	88	85	82	79	76	73	70	63	56	49	42	35	33	20	7									
5	97	94	91	88	86	83	80	77	74	72	65	58	51	45	38	32	25	12									
6	97	94	92	89	86	83	81	78	75	73	66	60	53	47	41	35	23	16	5								
7	97	95	92	89	87	84	81	79	76	74	67	61	55	49	43	37	26	14	9								
8	97	95	92	90	87	85	82	80	77	75	69	63	57	51	45	40	29	18	7	3							
9	97	95	93	90	88	85	83	80	78	76	70	64	58	53	47	42	31	21	11	1							
10	98	95	93	90	88	86	83	81	79	77	71	65	60	54	49	44	34	24	14	5							
11	98	95	93	91	88	86	84	82	80	77	72	66	61	56	51	46	36	26	17	8							
12	98	95	93	91	89	87	84	82	80	78	73	68	63	57	53	48	38	29	20	11	3						
13	98	96	93	91	89	87	85	83	81	79	74	69	64	59	54	49	40	31	23	14	6						
14	98	96	94	92	90	87	85	83	81	79	74	70	65	60	56	51	42	33	25	17	9	2					
15	98	96	94	92	90	88	86	84	82	80	75	71	66	61	57	52	44	35	27	20	12	5					
16	98	96	94	92	90	88	86	84	82	81	76	71	67	62	58	54	46	37	30	22	15	8	1				
17	98	96	94	92	90	89	87	85	83	81	77	72	68	64	59	55	47	39	32	24	17	10	4				
18	98	96	94	92	91	89	87	85	83	82	77	73	69	65	60	56	49	41	34	27	20	13	7				
19	98	96	94	93	91	89	87	86	84	82	78	74	70	65	61	58	50	43	35	29	22	15	9	3			
20	98	96	95	93	91	89	88	86	84	83	78	74	70	66	62	59	51	44	37	30	24	18	12	6			
21	98	96	95	93	91	90	88	86	85	83	79	75	71	67	63	60	52	46	39	32	26	20	14	8	3		
22	98	97	95	93	92	90	88	87	85	83	79	76	72	68	64	61	54	47	40	34	28	22	16	11	5		
23	98	97	95	93	92	90	89	87	85	84	80	76	72	69	65	62	55	48	42	36	30	24	18	13	8	3	
24	98	97	95	94	92	90	89	87	86	84	80	77	73	69	66	62	56	49	43	37	31	26	20	15	10	5	
25	98	97	95	94	92	91	89	87	86	84	81	77	74	70	67	63	57	50	44	38	33	27	22	17	12	7	3
26	98	97	95	94	92	91	89	88	86	85	81	78	74	71	67	64	58	51	46	40	34	29	24	19	14	9	5
27	98	97	95	94	92	91	89	88	87	85	82	78	75	71	68	65	59	52	47	41	36	30	25	21	16	11	7
28	98	97	95	94	93	91	90	88	87	85	82	79	75	72	69	65	59	53	48	42	37	32	27	22	18	13	9
29	99	97	96	94	93	91	90	88	87	86	82	79	76	72	69	66	60	54	49	43	38	33	28	24	19	15	11
30	99	97	96	94	93	91	90	89	87	86	83	79	76	73	70	67	61	55	50	44	39	34	30	25	21	17	13
31	99	97	96	94	93	92	90	89	88	86	83	80	77	73	70	67	62	56	51	45	41	36	31	27	22	18	14
32	99	97	96	94	93	92	90	89	88	86	83	80	77	74	71	68	62	57	52	46	42	37	32	28	24	20	16
33	99	97	96	94	93	92	90	89	88	87	83	80	77	74	71	69	63	58	52	47	43	38	34	29	25	21	17
34	99	98	97	95	93	92	90	89	88	87	84	81	78	75	72	69	64	58	53	48	44	39	35	30	26	23	19
35	99	98	97	95	93	92	90	89	88	87	84	81	78	75	72	70	64	59	54	49	44	40	36	32	28	24	20
36	99	98	97	95	94	92	90	89	88	87	84	81	78	76	73	70	65	60	55	50	45	41	37	33	29	25	21
37	99	98	97	95	94	93	91	90	88	87	85	82	79	76	73	70	65	60	55	51	46	42	38	34	30	26	23
38	99	98	97	95	94	93	91	90	88	88	85	82	79	76	74	71	66	61	56	51	47	43	39	35	31	27	24
39	99	98	97	95	94	93	91	90	88	88	85	82	79	77	74	71	66	61	57	52	48	44	40	36	32	28	25

BEST COPY AVAILABLE

SIMPLE KEY FOR FRESHWATER INVERTEBRATES

1 a Animal lives in a case of stones/twigs ..... Caddisfly larva
b Animal does not live in a case ..... Go to 2

2 a Animal has jointed legs ..... Go to 3
b Animal hasn't jointed legs 19

3 a Possesses six jointed legs (Insecta) 6
b Possesses eight jointed legs (Arachnida) 4
c Possesses more than eight jointed legs (Crustacea) 5

4 a The body is divided into abdomen and thorax ..... Water Spider
b The body has no obvious division ..... Water Mite

5 a Body flattened ventrally (ie. from side to side) ..... Freshwater Shrimp
b Body flattened dorsally (ie. from top to bottom) ..... Water Louse

6 a Adult insect with wings and hard wing cases 7
(If abdominal segments aren't visible, they are covered by wings)
b Not an adult insect, without wings 13

7 a The wing cases meet down centre of back (beetles) 8
b The wing cases escape 11

8 a Colour of body, slightly red ..... Screech Beetle
b No red colour 9

9 a A large beetle, > 3cm long ..... Great Diving Beetle
b A small beetle, < 3 cm long ..... Water Beetle

10 a Lives on the water surface ..... Pond skater
b Lives in the water 11

11 a Has a single 'tail' ..... Water Scorpion
b No 'tail' Has one pair of limbs longer than others 12

12 a Swims on its back ..... Greater Water Boatman
b Swims the correct way ..... Lesser Water Boatman

13 a Doesn't possess 'tails' ..... Beetle Larva
b Possesses 'tails' 14

14 a Only one 'tail' Gills along side of body ..... Alderfly Larva
b Two 'tails' 15
c Three 'tails' 16

15 a 'Tails' at least 1/3 body length ..... Stonefly Nymph
(Mostly found in moving water.)
b 'Tails' less than 1/3 body length ..... Beetle Larva

16. a. 'Tails', three or five sharp points ..... Dragonfly Nymph
    b. 'Tails', at least 1/4 of body length 17
17. a. Gills positioned on top of abdomen with hair-like tails ..... Mayfly Nymph
    b. No gills on top of abdomen. Flattened tails ..... Damselfly Nymph
18. a. Possesses a shell 19
    b. No shell 22
19. a. Shell consists of two parts hinged ..... Pea Cockle
    b. Spiral shell 20
20. a. Shell shaped like a ram's horn ..... Ramshorn Snail
    b. Not shaped like a ram's horn 21
21. a. Shell has a long spire ..... Great Pond Snail
    b. Shell has a short spire ..... Wandering Snail
22. a. Suckers on either end, moves by attaching them ..... Leech
    b. No suckers 23
23. a. Unsegmented, glides over river/lake bottom ..... Flatworm
    b. Segmented 24
24. a. More than 15 segments. No obvious head, moves slowly ..... Pondworm
    b. Less than 15 segments (Fly Larva) 25
25. a. With a large head. Body hanging upright from water surface ..... Mosquito pupa
    b. Not as above 26
26. a. Red body ..... Blood Worm
    b. Black body ..... Midge Worm
    c. Transparent body ..... Phantom Midge Larva

LIST OF PROTECTED SPECIES

1. WILD BIRDS

All wildlife birds (including native, migratory, vagrant and imported species) and their eggs, nests and young are protected **including** the following species:-

COMMON NAME	SCIENTIFIC NAME
Greater Black-backed Gull	Larus marinus
Lesser Black-backed Gull	Larus fuscus
Herring Gull	Larus argentatus
Pigeons including Woodpigeon but excluding carrier pigeons, racing/ homing pigeons or doves.	Columba palumbus
Carrion Crow	Corvus c. corone
Hooded (Grey) Crow	Corvus c. cornix
Rook	Corvus frugilegus
Jackdaw	Corvus monedula
Magpie	Pica pica
Jay	Garrulus glandarius
Starling	Sturnus vulgaris
House Sparrow	Passer domesticus

2. WILD ANIMALS (OTHER THAN BIRDS)

The following species are protected:

LAND MAMMALS	
Badger	Meles meles
Bat species	
Lesser Horseshoe Bat	Rhinolophus hipposideros
Leisler's Bat	Nyctalus leisleri
Common Pipistrells	Pipistrellus pipistrellus
Long-eared Bat	Plecotus auritus
Whiskered Bat	Myotis mystacinus
Daubenton's Bat	Myotis daubentonii
Natterer's Bat	Myotis nattereri
Deer Species	
Red Deer	Cervus elaphus
Sika Deer	Cervus nippon
Fallow Deer	Dama dama
Hare species	
Mountain Hare	Lepus timidus
Brown Hare	Lepus capensis
Hedgehog	Erinaceus europeus
Otter	Lutra lutra
Pine Marten	Martes martes
Pygmy Shrew	Sorex minutus
Red Squirrel	Sciurus vulgaris
Stoat	Mustella erminea

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MARINE MAMMALS

All whale species **(Cetacea)** including dolphins **(Delphinidae)** and Porpoises **(Phocaeidae)**.

Seal Species	
Common Seal	Phoca vitulina
Grey Seal	Haliochoerus grypus
REPTILES	
Common Lizard	Lacerta vivipara
AMPHIBIANS	
Common Frog	Rana temporaria
Common Newt	Triturus vulgaris
Natterjack Toad	Bufo calamita

3. WILD PLANTS

The following species are protected -

Alpine Poa	Poa alpina L.
Alpine Sassurea	(Saussurea alpine (L.) DC. (syn. Serratulla alpina L.)
Alpine Saxifrage	Saxifragra nivalis L.
Asparagus	Asparagus officinalis L.
Bog Hair-grass	Deschampsia setacea (Huds) Hack.
Bog Orchid	Malaxis paludosa (L.) Sw. (syn Orphyrs paludosa (L.) Hamarbya paludosa (L) O. Kuntze
Canadian St. John's Wort	Hypericum canadense
Chickweed Willowherb	Epilobium alsiniforium Vill. (syn E. alpinum Lpp)
Clustered Clover	Trifolium glomeratum L.
Common Rock-rose	Helianthemum nummularium L. Miller.
Cottonweed	Otanthus maritimus (L.) Hoffmans & Link. (syn Diotis maritima (L.) Desf ex Cass)
Dorset Heath	Erica ciliaris L.
Dropping Lady's Tresses	Spiranthes romanzoffiana Cham.
Forked Spleenwort	Asplenium septentrionale Hoffm.
Globe Flower	Trollius europeus L.
Gotlandian Dandelion	Taraxacum gotlandicum (Dahist.)
Greater Broomrape	Orobanche rapum-genistae Thuill. (syn O. major auct.)
Hairy Birdsfoot Trefoil	Lotus hispidus Desf. ex DC. (syn L. subbiflorus Lag.)
Hart's Saxifrage	Saxifraga hartii DA Webb
A Helleborine	Epipactis phyllanthes GE Sm.
Kerry Lily	Simethis planifolia (L.) Green & Godr.
Killarney Fern	Trichomanes speciosum Willd. (syn T. radicans auct.)

Hoary Rock-rose	Helianthemum canum (L.) Baumg.
Irish Hydrilla	Hydrilla verticillata (L.fil.)
Irish Sandwort	Arenaria ciliata L. incl. spp. hibernica Ostent &
Lanceolate Spleenwort	Asplenium billottii F. Schutz (syn A. obovatum Viv; A. lanceolatum Huds.
Limestone Fern	Gymocarpum robertianum (Hoffm.) Newm. (syn Thelpteris robertiana(Hoffm.) Sloson
Little Robin Cranesbill	Geranium purpureum Vill.
Marsh Pea	Lathyrus palustris L.
Marsh yellowcress	Rorippa islandica (Oedex ex Murray Borbas)
Northern Rockcress	Cardaminopsis petrae (L) Hilt
Opposite-leaved Pondweed	Groenlandica densa (L.) Fourr. (syn Potamogeton denus L.; P. serratus L.)
Paradoxical Rock Sea-lavender	Limonium paradoxum Pugsl.
Pennyroyal	Mentha pulegium L.
Perennial Glasswort	Arthrocnemum perene (Miller) Moss (syn Salicornia perennis Mill.)
Pillwort	Pilularia globulifera L.
Purple Milk-vetch	Astragalus danicus Retz.
Pyramidal Bugle	Ajuga pyramidalis L.
Recurved Sandwort	Minuartia recurva (All.) Schinz & Thell.
Round-leaved Wintergreen	Pyrola rotundiforia L.
Seakale	Crambe maritima L.
Sea Knotgrass	Polygonum maritimum L.
Sea Pea	Lathyrus japonicus Willd.
Slender Cotton Grass	Eriophorum gracile Roth.
Slender Naiad	Najas flexilis (Willd.) Rostk & Schmidt
Subterranean clover	Trifolium subterraneum L.
Tea-leaved Willow	Salix phylicifolia L.
Three-lobed Water Crowfoot	Ranunculus tripartitus DC.
Western Rock Sea-lavender	Limonium transwallianum (Pugsl) Pugsl.
Wild Sage	Salvia horminoides Pourr.
Willow-leaved Inula	Inula salicina L.
Yellow Marsh Saxifrage	Saxifraga hirculus L.

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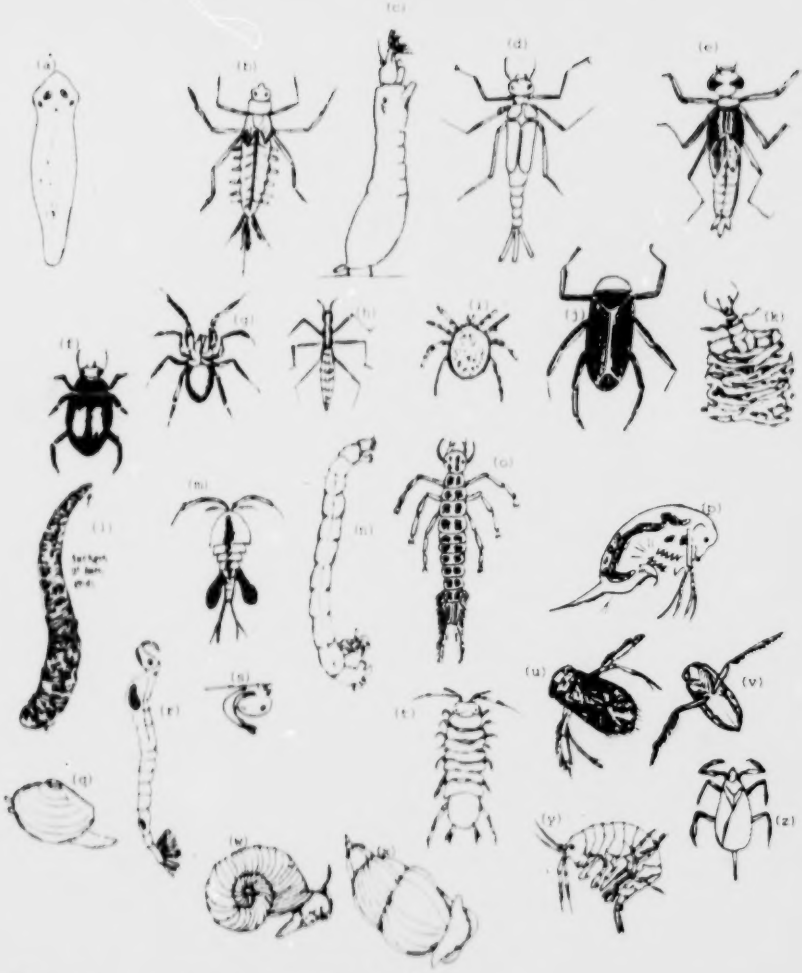


Fig. 42 FRESHWATER ANIMALS

(a) Flatworm (up to 15mm). (b) Mayfly Nymph (8-11mm). (c) Blackfly larva (8mm). (d) Damselfly Nymph (up to 45mm). (e) Dragonfly Nymph (up to 50mm). (f) Waterbeetle (up to 11mm). (g) Waterspider (12-14mm). (h) Watermeasurer (8-11mm). (i) Watermite (up to 1.5mmP. (j) Great Diving Beetle (30-35mm). (k) Caddisfly Larva in case (20-25mm). (l) Leech (100-150). (m) Cyclops (up to 2mm). (n) Bloodworm (15-20mm). (o) Great Diving Beetle Larva (60-70mm). (p) Waterflea (up to 5mm). (q) Cockle (up to 10mm). (r) Phantom Midge Larva (10-12mm). (s) Mosquito pupa (up to 8mm). (t) Freshwater Louse (up to 15mm). (u) Lesser Waterboatman (15-16mm). (v) Greater Waterboatman (15-16mm). (w) Ramshorn Snail (35mm). (x) Great Pond Snail (50-60mm). (y) Freshwater Shrimp (up to 20mm). (z) Water Scorpion (up to 20mm).

Investigation No. 13(a)

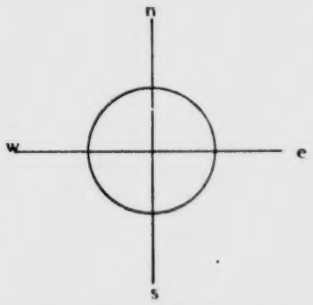
Sheet to record % cover values of lichens, slope of tree and light in four quadrants.

Precise Location	School
	Date
Host Species	Girth in m :

Epiphyte type	n	s	e	w
Total				

Direction of slope (°)	Amount of slope (+/- °)

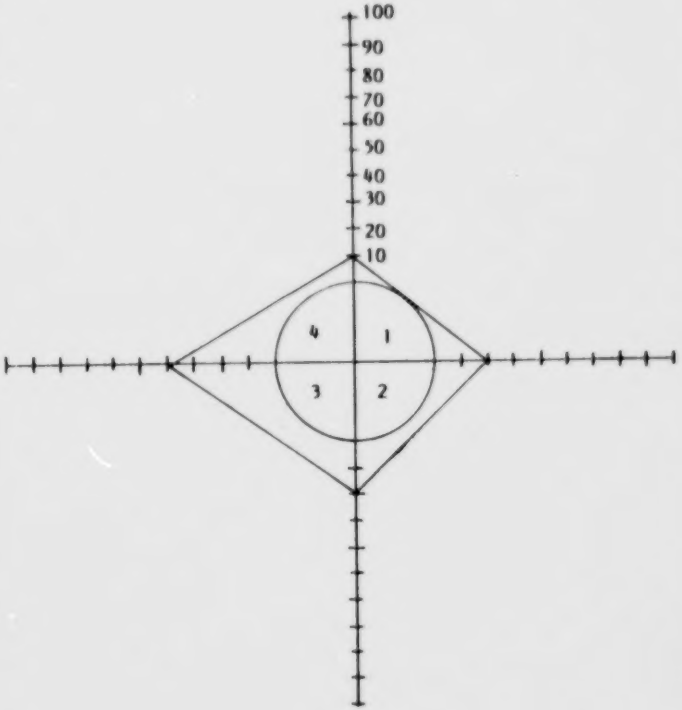
Light reading in each quadrant



Investigation No. 13(b)

Sheet to map distribution of lichens around trunk of a tree at a selected height above groundlevel (GL).

Precise Location		School
Map ref.		Date
Host Species	Girth in m :	Height in m above GL



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